THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 63 Thursday, September 19, 1940 No. 1257

PUBLISHED WEEKLY

Subscription Terms (Home and Overseas) : 21s. per annum.
All Subscriptions are payable in advance.

THE FOUNDRY TRADE JOURNAL
49, Wellington Street, London, W.C.2.

EMERGENCY ADDRESS
to which all communications should be sent until further notice :—
3, Amersham Road, HIGH WYCOMBE, Bucks.
Telegraphic Address : "Zacatecas, High Wycombe."
Telephone : HIGH WYCOMBE 1792 (3 lines).

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A Year of Metal Control

Periodic reviews of the activities of Government controls as applied to industry sometimes provoke a type of criticism which smacks of the post-mortem, but it is pleasant to reflect that thoughts of this kind do not crop up in relation to consideration of the work performed by the Controller of Non-ferrous Metals. This particular section of the Ministry of Supply is a long way from a post-mortem, for it is very much alive and operating a system which has, as it were, "ran itself in" during the first year of the war. Some day, perhaps, in the precise phraseology of an official report, we shall be given facts and figures concerning the vital work performed by the Control in non-ferrous metals, but at present the unrolling vista of war lies between conjecture and fact. Figures may be released before the conclusion of hostilities, but the time is not yet opportune to tell the world of the remarkable task achieved by the Ministry of Supply in furnishing the necessary raw materials for the fabrication of the essential munitions of war which will bring victory and peace in due course. After twelve months of hard going there are most encouraging signs that the Non-ferrous Metal Control is on top of its job.

In reviewing the developments in the metal industry during the twelve months that have gone by since September last year, full credit must be given to the spirit of co-operation displayed by the consumers of the base metals in this country. When war came the change-over from free trading to a system of rationing and licensing was of necessity sudden, and inevitably there were some difficulties and misunderstandings at the onset. Much of the success of the scheme has arisen because all concerned have done their utmost to make short work of difficulties in the light of the urgent national need, and when that spirit is apparent, success is assured. When the supply position *vis-à-vis* the tonnage of raw material available became such that some kind of rationing was essential, the Control found it necessary to call for the submission of full details of every order, and it was feared at first that the amount of clerical work involved would be very heavy, but after ideas had been clarified the scheme was adopted and has worked smoothly on the whole. As the months have passed the proportion of orders for the Services and other essential wartime requirements has increased, while with the whole-time harnessing of the industrial energies of the nation the day cannot be far distant when every ton of material turned out will be serving the war machine in one way or another.

Another, and perhaps the most important function which the Control has fulfilled, is the question of fixing maximum price limits, and in this there cannot be any doubt that the arrangements for bulk purchases of copper, lead and zinc within the Empire have proved of inestimable value to this country. Even after the upward adjustment in prices last December, the quotations for all three metals are essentially reasonable in all the circumstances, but it is felt in some directions that the advance made in zinc and lead was overdone. The sequel to the collapse of France has been more copper for this country, and at the same time the export quotation in the United States has suffered a relapse, but even so the prices paid by consumers in the United Kingdom are below what may still be called "the world price." It is possible that a certain amount of American electrolytic copper has been purchased, but the basis of the non-ferrous metal supplies has been and still is the British Empire, and news has just come through that the contract with Rhodesia has been renewed for another twelve months. Moreover, the output from both Africa and Canada would appear still to be growing, so that the second year of control in non-ferrous metals can be envisaged with full confidence in the supply position.

The onus placed upon the other Controls in which the foundry industry is interested is of a different character, as the materials which they handle are for the most part home-produced. The object of the Control of Iron Castings has been to limit the production of non-essentials so that the munition works may have ample stocks. The pig-iron and scrap Controls have undertaken the distribution of these essential raw materials. For the earlier months, their task was relatively easy, but in recent times reservation has had to be made to conserve stocks for essential war purposes. The steel castings section has had the additional task of greatly expanding output, and there is every indication that its work has been highly successful.

In general it can be stated that the Controls have responded excellently to the demands placed upon them during the last twelve months.

D

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

A Lost Art?

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have been connected with welding for many years and from time to time I have written articles describing some of the many repairs with which I have had to deal, particularly cast-iron repairs. During these years I have read many books on welding, and have always been striving to learn as much as possible about the art of welding. I have taught welding to others, and I feel that, so far as welding is concerned, I was fairly well advanced in knowledge. Had I not been so advanced I would not have dared to write about it and give advice so frequently as I have done.

Looking through THE FOUNDRY TRADE JOURNAL for August 29, I chanced upon an article entitled "A Lost Art?" After reading this article I felt inclined to say, "Here is another American tall story," but on second reading I was struck by the note of sincerity which seems to run through the comments of Mr. P. Hall; surely such a man would hardly make his comments without some foundation, and I began to think more deeply about it.

Welding cast iron successfully without the application of heat seems to verge on the fantastic, and one feels that welding cannot be carried out without heat. As the man who had a secret method appears to have been a welder, we can assume that he did use heat. This assumption is supported by the sentence which states that the enamel on the engine cylinder was not even discoloured from the cylinder being slightly heated. So we find that heat was used.

In present-day practice using the low-temperature process of welding by a proprietary electrode it is possible to weld cast iron without unduly disturbing any coating, enamel or other, on the main part of the article outside an area approximately 2 in. from the welding zone. So perhaps some earlier form of this type of welding was used.

Stress seems to be placed on the tests of hydraulic pressure which broke the casting not on the weld or the patch outside this area. I would like to point out that repairs on cast iron when carried out by any of the modern welding processes very rarely fracture at the actual weld, but more often when subjected to destructive hydraulic tests fail adjacent to the weld, which appears to have occurred in the first experiment mentioned in the article.

Mr. Hall states in his comments that about eight years ago he visited a man in the Chevrolet gear and axle plant, Detroit, and spoke to him concerning the welding of cast iron. It appears that this man told him that no one could weld cast iron properly as the structure made it impossible to weld.

It would seem from this remark that Mr. Hall went to the wrong place when he went to Detroit, because I myself have been welding cast iron successfully for the past 14 years, and the company for whom I now work have been manufacturing cast-iron welding rods and supplying them to welders for over 20 years. During this period many thousands of successful cast-iron welding repairs have been carried out, and the industries in this country have saved perhaps hundreds of thousands of pounds through this welding process.

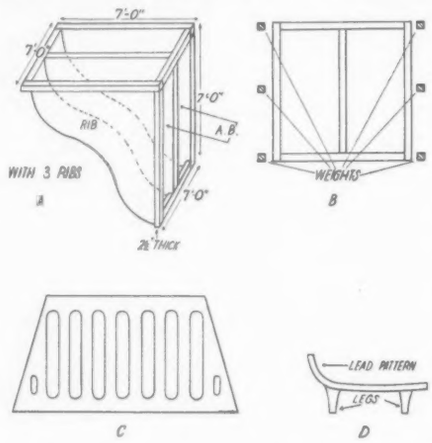
In the light of my above remarks and Mr. Hall's comments, I would suggest that there is no "lost art," and that the secret did not die when this man passed out of the picture, but that the "secret" is very well known to thousands of welders in this country and is used every day in the repair of cast-iron articles which have been broken. Furthermore, it is generally the case that a cast-iron weld when properly made is stronger than the surrounding iron.—Yours, etc.,

E. CHRISTIE
(Technical Service Department, Suffolk Iron Foundry (1920), Limited),
Sifbronze Works,
Stowmarket.

Some Jobbing Foundry Experiences

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—As a foundry foreman of the younger school, I have been very interested in the series of articles by "Tramp." In the first one, he wrote of the use of loam plates, when the facilities afforded by top boxes are not available. The following is a description of a personal experience of a few years ago as a young tradesman. The job in question, a 7-ft. square angle plate, needed a loam plate. It was a one-off job, and the patternmaking costs had to be kept to a minimum. It was made in the form of a frame, as shown in Fig. A, and was bedded in the floor with a board A-B at the back. This was reinforced by ramming in weights at the side of the mould, as is shown in Fig. B. After ramming up, the top face was strickled



and backed off, the pattern was raised, and a plain top was rammed up. The loam plate, which was made about 8 ft. 6 in. by 7 ft. 6 in., was inserted at the back of the mould against the weights. The back of the plate having been filled up with sand and more heavy weights, the mould was closed. The resulting casting was in every way successful.

In the fourth article, "Tramp" discussed firebars, and here again quite recently, as foreman, I was asked to make a well grate, for which the only pattern available was of the flat type, shown in Fig. C. To overcome the difficulty, a cardboard template of the flat grate was prepared, and from it was cast a pattern in soft lead. The front of this was then beaten to conform to the required angle. The patternmaker next provided some loose legs, shown in Fig. D. Once again a good casting was made without having to incur the cost of patternmaking.—Yours, etc.,

TREVOR WILLIAMS.

Swansea.

Catalogue Received

Vacuum Waxes and Greases. A card folder from W. Edwards & Company (London), Limited, of Southwell Road, Loughborough Junction, London, S.E.5, details the properties and uses of "Apiezon" products—a series of oils, greases and waxes used in connection with high-vacuum work. A covering letter explains that this type of substance was previously imported from Germany.

Random Shots

"Marksman" has made what he believes to be a unique discovery which should interest the many stamp collectors in the industry. It is a defect in a modern French pictorial, and is worthy of note as it seems to have a curious prophetic significance. The stamp in question was one issued on the occasion of the Royal visit to France, symbolising the Anglo-French alliance. In one copy in "Marksman's" possession the outer frame, instead of being continuous, is quite distinctly broken along the top between the RF monogram and the ribbon of the central seal of friendship.

* * *

The season generally known as the "Fall" is fast approaching. It is the time when one can expect to see the leaves falling from the trees and German bombers from the skies.

* * *

The Bigger Pest!

A man in the works the other day was telling his mate what a bad night he had had in the previous night's air raid. "It was a hot night," he explained, "and the shelter was full of the missus and kids, so I wrapped myself in a rug and lay down just outside the entrance ready to pop in if necessary. Well, it wasn't so much the sirens or the thud of the bombs or even the sound of the guns that upset me, but the noise of those blinking caterpillars munching away at my brussels sprouts fairly drove me mad!"

* * *

A melter on night shift on an electric furnace was discussing with his mate how to distinguish the sound of German machines from the British during a night raid. "Is the Jerry," asked he, "the one that sounds like a finishing slag, or is it the one that sounds like a boil off the bottom?"

* * *

"Chambermaid wanted at once to sleep in box 645," reads a small advertisement. It is reported that several girls applied for the job, but without exception asked if they could sleep in the cellar instead.

* * *

Following a recent air raid in one part of London the most popular place was the local cinema, which was showing the film "Gaslight." The supporting film was, ironically enough, called "Thou Shalt not Kill"!

* * *

In the same district, displayed in a stationer's shop the morning after, was the notice: "No papers yet, but plenty of fags and baccy. Buy these and be happy."

* * *

History repeats itself. A block of flats newly erected in a London suburb has been named Stanton House. The name of the resident letting agent is Mr. Miles! Incidentally, what a pleasant change a sensible name like Stanton House makes in a district which sports such names as Embassy Court and Viceroy Lodge. There is even a St. James' Court, which being only a row of flats over a shopping parade, is usually referred to by the residents of its more pretentious neighbours as the Court of St. James!

"MARKSMAN."

THE RED CROSS PENNY-A-WEEK FUND has set itself the task of registering the five millionth regular contributor by the end of the year. If this aim is achieved the workers of Britain will be contributing nearly £21,000 a week to Red Cross funds, or rather more than £1,000,000 a year. Employers are urged to send for details of the scheme to the Red Cross Penny-a-Week Fund, 89, Kingsway, London, W.C.2.

Bells of Japan

By J. R. NICHOLS

The use of bells—great and small, for various purposes—has been practically world-wide from very early times, and their manufacture a metallurgical art perfected many centuries ago. The oldest known bell in the world is one now in a Berlin museum, this being a 3,000-year-old example of the bell-founder's art from Ancient Babylon.

The casting of bells, particularly those of large size, was common in the East long before it was attempted in the Western world, and many fine bells exist in Eastern parts to-day, some being of extremely early date. A private collection contains a small Chinese handbell thought to be of the Shang Yin period (? 1766-1122 B.C.). Bells were used in China 2,000 years before the Christian era. Neither in the East nor in the West has the long-accepted shape undergone any drastic change throughout the centuries, although the conventional shape of the bells of China and Japan is not that of the European bells. The bells of the East are longer in proportion to the diameter at the mouth; the mouth itself is not flared, that is to say, there is not so great a difference relatively between the diameter at the mouth and that at the crown.

Many large bells similar to that shown in Fig. 1 exist in China and Japan, and some are of early date. The large bells serve as temple bells, but other varieties are also in use, such as those known as *wanaguchi* (literally, "crocodile mouth," so called from the slot which extends for half of the circumference on the lower side). Fig. 2 shows such a bell, this dating from *circa* 1650. A large number of *wanaguchi* are to be found in various parts of Japan, many of them bearing inscriptions, and ranging from three to six centuries old. An interesting variety, too, is found in the different kinds of handbells, Fig. 3 showing a form of handbell known as a *gokosuzu*, this particular specimen being of Chinese workmanship.

Bells and gongs are also found in other forms, such as rattles having several small bells, and gongs somewhat resembling cauldrons. It is, however, in the larger type of bell that the greatest interest will be found, since these are often of notable weight, this alone showing that the foundrymen of bygone days had an excellent knowledge of their craft. As with the stained glass windows, sculptures and carvings of European cathedrals and churches,

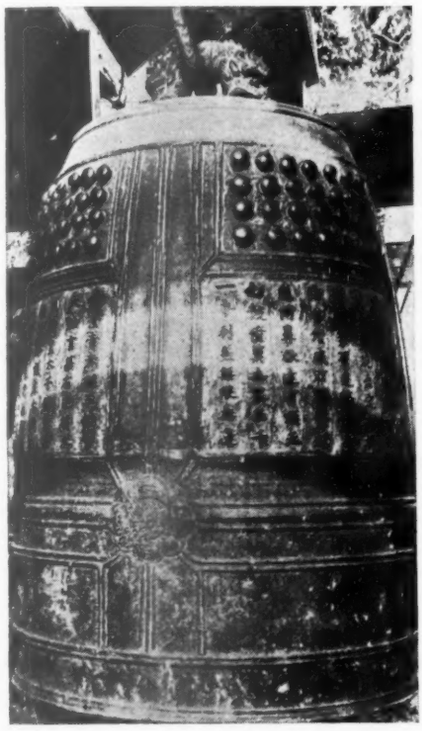


FIG. 1.—TEMPLE BELL OF EIZANJI AT GOJO IN THE PROVINCE OF YAMATO. CAST IN THE ENJI PERIOD, A.D. 901-923.

FIG. 2.—WANAGUCHI AT ASAHIMURA KAWATA-GUN. CAST ABOUT A.D. 1650.

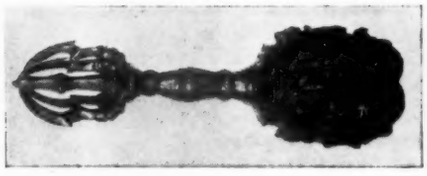


FIG. 3.—GOKOSUZU OF CHINESE ORIGIN (A.D. 620 TO 901).

FIG. 4.—BELL, WEIGHING 52 TONS, CAST IN 1935 AT KYOTO BY MR. TAKAHASHI.

FIG. 5.—SECTIONS OF THE MOULD FOR THE BELL SHOWN IN FIG. 4 READY FOR ASSEMBLY.

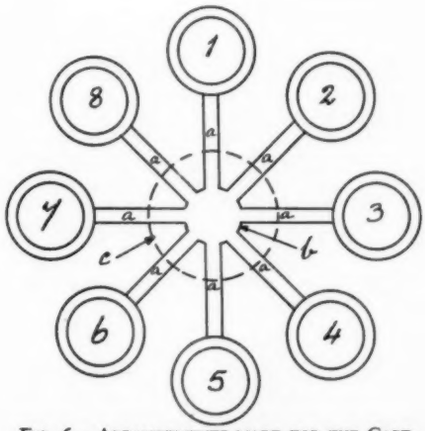


FIG. 6.—ARRANGEMENTS MADE FOR THE CASTING OF THE BELL SHOWN IN FIG. 4. 1 TO 8, MELTING FURNACES; *a*, DUCTS FROM THE FURNACES TO THE MOULD; *b*, RUNNER BOX; AND *c*, MOULD FOR THE BELL.

so with the temple bells of Nippon, which oftentime give permanent record to incidents in their country's story; famous scholars and poets have written the inscriptions, and the bell-founders have painstakingly reproduced them upon their bells.

Just as tradition has established names for the various parts of our bells, so with the bells of old Japan. The loop by which they are hung, called by us the "canons," becomes the *rindzu, i.e.,* the dragon's head, and is usually modelled to consort with its name. The upper part bearing the studs is called *chichinoma,* and below this there is a space called *ikenoma,* whereupon one finds the inscriptions and pictorial decorations, this part corresponding to the "waist" of European bells.

The Japanese, having realised the artistic merit of their ancient bells, have very wisely scheduled many of them as National Treasures, to be carefully preserved for all time. Some bells in Japan of considerable antiquity are of Chinese and Korean manufacture.

it is composed of about 44½ tons of copper and 6¾ tons of tin. For the melting of the metal 32 tons of coke and 1,000 bundles of firewood were used. This bell ranks among the largest in Japan, and its maker, Mr. Takahashi, is seen standing beside it.

The moulds for large bells are made in parts, Fig. 5 showing the outer parts of the mould for this particular bell. The mould is assembled in a pit, around which the furnaces are erected. In this particular case, eight furnaces were used, each having a duct leading to a common central runner basin, disposed above the crown of the bell. In order to attend to the furnaces a staging is built around the outside of the circle they form. Blast is provided by belt-driven blowers, the air passing into the circular tuyere situated some little distance above the bottom of the furnace. The sketch (Fig. 6) shows the plan of the furnaces.

A list of some of the notable bells of Japan is appended.

Bell.	Date.	Weight. Tons.	Height. Ft. In.	Dia. Ft. In.	Thickness. In.
(i) Temple bell of Shitenoji	1902	155	26 0	16 0	18
(iii) „ „ „ Chion-in	1633	74	10 8	9 0	9.5
(iii) „ „ „ Hokoji	1604	63	14 0	9 0	9
(v) Bell by Mr. Takahashi	1935	52	12 0	9 2	?
(v) Temple bell of Todaiji	732	37	?	?	?

Alterations in Income Tax Procedure

By F. J. TEBBUTT

With two new Finance Acts in one year, confusion is apt to arise concerning tax payments, especially when the second Act alters the tax poundages of the first (as now) without those poundages having taken effect. It is hoped that these brief notes concerning the position of taxpayers (by Finance Act (No. 2), 1940), under Schedule D (business profits; persons on own account) and Schedule E (employments), as regards January 1 and July 1, 1941, payments, may be useful. For these 1941 payments the standard rate is 8s. 6d. (increased from 7s. 6d.) and the reduced rate 5s. (from 2s. 4d.). Thus the poundage increases on 1940 payments are 1s. and 2s. 8d. respectively, but the reduced rate will apply to the first £165 of taxable income instead of £135 as formerly.

An important new provision makes compulsory the deduction of tax from payments for salaries and wages by employers (under penalties), but only in respect of Schedule E income. Thus, if the employee has income from any other source, that will not be deductible under this new rule, and the employer will not know of such income. Assessments will still be made by the tax authorities, the employer having nothing whatsoever to do with assessments or returns of income. The employer will be notified of the total amount of tax payable by the employee, and he will be called upon to divide it into equal amounts according to the number of pay days (*e.g.,* weekly or monthly).

Where the employee is ordinarily assessed (*i.e.,* yearly assessments) the employer will be notified the amount in October, and tax due on January 1 following will be deducted in the months November to April. As regards the July 1 instalment, notification will be made in the previous April, and deductions will be made in the months May to October following. If the employee comes within the term "weekly wage earners" (*i.e.,* manual workers), who are assessed half yearly (April 5 and October 5), the January 1 payment will be deducted in the months January to June, and the July 1 payment in the months July to December. The employer is required to pay over the cash collected during any month by the seventh day of the succeeding month.

(*Continued on page* 192.)

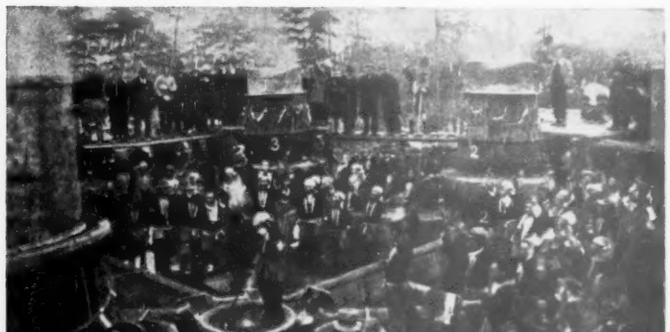


FIG. 7.—GENERAL VIEW OF THE CASTING OF THE BELL SHOWN IN FIG. 4. THE SCHEME IS BEST APPRECIATED BY CORRELATING WITH FIG. 6.

FIG. 8.—APPEARANCE OF THE BELL BEFORE FETTLING.

A notable difference between the bells of the East and those of the West is found in the composition of the alloy. Whereas with European bells it is customary to make bell-metal of approximately 13 parts of copper to 4 of tin, in Chinese and Japanese bells there is usually a much greater proportion of copper. An ancient Chinese document recommends 5 parts of copper to 1 of tin for bells and cauldrons. It is considered that the tone of Chinese and Japanese bells is of more sombre quality than that of European bells, and it may be that the increased proportion of copper accounts for this, since the tin (while rendering the alloy more brittle) also increases the brilliancy of the tone.

A Modern Bell

In the large bell shown in Fig. 4, cast a few years ago, the proportion of copper is even higher, being in the ratio of 6.65 to 1. A few notes respecting this bell may be of interest. Cast in 1935, by Mr. Takahashi, a bell-founder of Kyoto, it is of approximately 52 tons weight; its height is 12 ft. and its diameter 9 ft. 2 in.; No. (i) is cracked, and is appropriately called *Narazukane,* or "the bell that will not ring."

With regard to suspension, since the bells of the East are hung "dead," and not to swing as English bells do, it is not necessary to make provision for pivoted headstocks, bearings, wheels and other equipment. The method of sounding is entirely different from ours; a huge baulk of timber is suspended in a convenient position near the bell, and this is drawn away and allowed to swing back, to strike the bell on the outside. Consequently, Japanese bells are not provided with internal clappers.

Figs. 5, 7 and 8 show stages in the casting of a large modern Japanese bell. In Fig. 5 is shown the mould (in sections) in course of preparation. Fig. 7 illustrates the actual casting operation, made more plain by reference to Fig. 6, and in Fig. 8 is shown the bell casting just as it has been removed from the mould. From these three photographs it will be seen that the present-day Japanese bell-founder has lost nothing of the art of making bells in the traditional style, as made by his ancestors at least 1,300 years ago.

Commercial Pearlitic Malleable Irons

In our issue of August 29 we published an abstract of a Paper on "Properties of Commercial Pearlitic Malleable Iron," which Mr. C. H. Lorig presented to the annual meeting of the American Society for Testing Materials. The following written discussion of the Paper is taken from last month's "A.S.T.M. Bulletin."

"Expected Values" and Specifications

DR. H. A. SCHWARTZ (manager of research, National Malleable and Steel Castings Company, Cleveland, Ohio) wrote to express his appreciation and that of Committee A-7 to Mr. Lorig for having prepared so complete a correlated abstract of the present state of knowledge regarding the pearlitic malleables. Particular attention was drawn to the statement in small type below the caption of a table in the Paper which cautioned the reader against using the recorded physical properties as the basis for drawing specifications. Such a table, giving what might be regarded as expected values, would of necessity exclude probably half of the production of the product since, in general, as many results would fall above as below the expected values. The result might become even worse in cases where one property went up while the other one decreased. It was imaginable that in such a case where the correlation was close between two properties and the average value exactly determined, a specification would exclude one half the samples for one cause and the other half for another cause.

Mr. Lorig had laboured under great difficulty because many manufacturers of pearlitic malleable did not wish to publish sufficiently exhaustive investigations of the properties of their product. He wished neither to condemn nor to endorse such an attitude. It was but natural that each producer should act according to his own interests in this matter as his judgment dictated. However, until more thorough and exhaustive investigation of the effect of graphitising and other heat-treating processes on at least unalloyed white iron was undertaken, there would be no possibility of writing intelligent specifications.

A further fact to be considered was that these products were manufactured largely to suit specific purposes, and it might always be necessary to keep specifications covering a rather wide range and combinations of properties.

Machinability of Pearlitic Malleable

MR. H. OSBORG (technical director, Ferrous Metals Corporation, New York, N.Y.) wrote that the author had rendered an invaluable service to metallurgists and engineers by presenting a critical review on so-called pearlitic malleable irons. His effort was particularly appreciated considering that in some cases but fragmentary evidence had been made available to him.

Though the common denominator, pearlitic malleable irons, did not strictly apply to all of the products included, it might serve a practical purpose to have ductile iron castings containing, besides graphite, cementite in spheroidised form tentatively included under that heading. However, it should not be overlooked that spheroidised cementite was the result of a spheroidising treatment to which pearlitic or martensitic iron had been subjected.*

The ease with which pearlitic malleable irons could be machined was recognised. In order to substantiate this, the relative machinability of so-called pearlitic malleable irons had been determined some time ago under strictly comparative conditions, using high-strength cast iron, malleable iron, cast steel, and a pearlitic malleable iron for such tests. The specimens for these tests were rollers measuring 11 in. in outside diameter with a 4-in. face, cast from the various materials to be tested, and properly annealed, or heat-treated, bored, faced and fitted, and were then placed between lathe centres. A condensed summary of the test results was given by Mr. Osborg as follows:—

Material.	Average Brinell hardness.		Average watt hours per cubic inch of material removed.	Machinability ratings.
	Before.	After.		
High-strength cast iron* ..	200	181	6.31	1
Malleable iron ..	137	130	6.54	2
Cast steel† ..	153	149	9.24	6
Pearlitic malleable iron (Z-metal)—				
Straight ..	211	229	9.00	4
0.5 per cent.Cu	229	233	9.18	5
1.0 per cent. Cu	200	210	7.70	3

* About 40 per cent. steel added to cupola mixture; approximately 3.15 per cent. carbon, 2.10 per cent. silicon, remainder of analysis normal for cast iron; samples tested in the "as-cast" state. (Range of ultimate tensile strength, 18 to 22 tons per sq. in.)
† 0.25 per cent. carbon steel; samples tested in the "annealed" state.

From that summary it became apparent that the so-called pearlitic malleable iron used in these tests machined somewhat harder than the high-strength cast iron and malleable iron, but was easier to machine than cast steel, even though it was much harder. Of interest also was the relative effect of the copper content on the machinability, showing a decided improvement in machinability of the copper-bearing material after the copper addition had appreciably exceeded the solid solubility range of copper in the iron.

In commercial production work Z-metal having a Brinell hardness of 170 to 180 was regularly machined at higher cutting speeds (dry) than forgings of S.A.E. 1020-1030 steels, which were considerably softer.

Elastic Limit and Yield Point

Commercial cylindrical castings having low wall ratio were subjected recently to exacting and extensive hydraulic tests. Two particular features of the various results obtained might be of interest. It was definitely established that the pearlitic malleable iron, which in this case was of the spheroidised type, was in all cases entirely free from porosity up to the point of bursting (19.1 tons per sq. in. for castings not machined, $\frac{1}{4}$-in. wall thickness; and 11.5 tons on machined castings, having $\frac{7}{16}$-in. wall thickness). When plotting pressures against the expansion of the outside diameter of the casting, the slope of the plot changed only slightly after the elastic strength was exceeded, which indicated a material that work-hardens at a very great rate. Therefore, if a tension test-bar was considered, it became evident that the straining of the specimen from its elastic limit to 0.005 in. per inch strain required a considerable increase in load. This fact accounted for the great difference between elastic limit and yield point which had been observed in this type of pearlitic malleable iron.

* "Metals Handbook" (1939 edition), p. 10: "*Spheroidal or Spheroidised Cementite*: The globular condition of iron carbide resulting from a spheroidising treatment (see under annealing). The initial structure may be either pearlitic or martensitic. Note: The term 'spheroidised pearlite' should be avoided, even when the structure is undoubtedly the result of spheroidising anneal of a pearlitic steel. The term 'spheroidite' has been proposed."

Wearing of Rubber Gloves

The nature of some processes sometimes makes it impossible for workers to avoid wearing rubber gloves practically all day long. As the rubber is completely impervious, discomfort is caused by perspiration, particularly if the process is warm or hot, or involves much physical exertion. One firm has found a very great increase in comfort by the issue of stockinette inner gloves to all employees who have to wear rubber gloves for long periods.—"Industrial Safety Bulletin."

Working after the Siren

AN INDUSTRIAL WARNING SYSTEM

This country has now had several weeks of the Nazi air attack. Our defences and our people have stood the test, and very severe losses have been inflicted upon the enemy. Even greater tests may lie ahead, and in order to meet them and to develop our counter-offensive it is essential that there should be the least possible interruption in all work vital to the country's needs.

The Government is therefore confident that all employers and workers on essential work, including export trades, will be willing, wherever possible, to carry on after the siren until it is clear that enemy attack is imminent, and to resume work when the immediate danger has passed without waiting for the public "Raiders Passed" signal.

For this purpose an industrial warning system is needed within the framework of the existing system of public warning by siren. Hence-forth the warning by siren will be regarded as an Alert and not as an Alarm signal. In this way we can combine maximum industrial output with the greatest possible protection for those at home. There is no room for foolhardiness or the taking of unnecessary risks, and to keep down the risks involved it is essential (1) that watchers should be placed on roofs or other vantage points to give warning of danger, and (2) that protection should be provided at or near the actual work places.

A MESSAGE FROM THE PRIME MINISTER

Experience of the last few weeks has taught us that one of our greatest problems in this country is to maintain our production in spite of air raids.

Representatives of the Trade Union Congress, the British Employers' Confederation, the Federation of British Industries and the Association of British Chambers of Commerce have been in consultation with the Government in an effort to produce the best system to meet this problem. The proposals they recommend are with this note.

Experience may show that the system is capable of improvement, but let us co-operate to make it work so as to minimise the dangers of surprise in these destructive attacks from our cruel and relentless enemy. Together, this plan was drawn up by employers and employed alike. So let us all work it together, improving it where we can in the light of experience, till victory comes.

(Signed) WINSTON S. CHURCHILL.

Working after the siren will not affect workers' rights to compensation for personal injury under the Government scheme or their rights under any known life insurance policy which covers war risks; nor does it affect the employers' position under the Personal Injuries (Emergency Provisions) Act.

Watchers

(1) Watchers for duty by day or by night should be selected by agreement between the management and the workers.

(2) They should be able to reach shelter quickly from their posts and, if necessary, shelter should be specially provided for them.

(3) Watchers should act on evidence of enemy activity in the neighbourhood, such as gunfire, bombs, flares and searchlights. They can start at once, but the R.A.F. is prepared to provide training.

(*Continued on page* 198.)

Radiography with Ultra-High Voltages

IMAGE OBTAINED THROUGH NINE INCHES OF STEEL

Recently an X-ray equipment rated for a maximum potential of one million volts was completed for installation in one of the cancer hospitals at Hamburg. Before its installation, it was placed at the disposal of the Reich X-ray department of the Materialprüfungsamt at Berlin-Dahlem, where, using voltages up to the maximum, it was used to test the penetrability of steel and the feasibility of detecting defects and faults at the higher voltages. An account of this work is given by R. BERTHOLD, E. EBERT and O. VAUPEL in a Paper in "Stahl

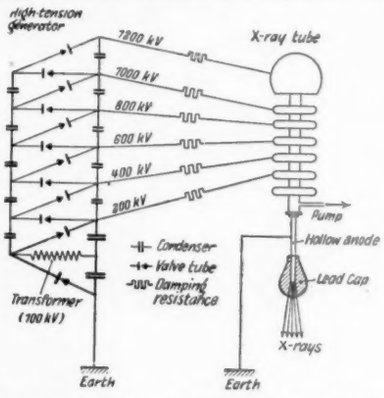


FIG. 1.—CIRCUIT LAYOUT OF SUPER HIGH-TENSION X-RAY EQUIPMENT.

und Eisen," from which the following is a summary.

In this equipment the high-tension generator consists of a transformer rated for 100 kv., which by means of a cascade circuit and condensers and valve tubes in six stages, and utilising both phases, can be raised to 1,200 kv. above earth potential. The X-ray tube is also of six-stage construction, each stage being connected to the corresponding stage of the high-tension generator (see Fig. 1); it has an earthed hollow anode with the focus at the end. The diameter of the focus is 10 to 12

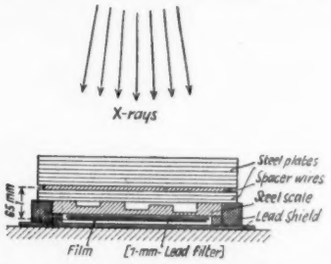


FIG. 2.—ARRANGEMENT FOR DETERMINING THE THICKNESS OF STEEL PENETRATED AND ABILITY TO DETECT FAULTS.

mm. on a continuous load of 5 milliamps. The tube, which is continuously connected to a vacuum pump, can carry the full potential of 1,200 kv. on no-load. At 5 milliamps there is a reduction in potential to 1,000 kv., and as the circuit of the equipment is connected on the Greinacher principle, the tube voltage remains constant. As the "through-pull" or magnification factor ("Durchgriff") of the tube is lower than with standard tubes, X-rays commence to be emitted only from 400 kv. onward. The radiation emitted is filtered through 2-mm. tungsten, 10-mm. copper and 40-mm. water, this preliminary filtering corresponding to about 19 mm. of steel at voltages between 500 kv. and 1,000 kv.

To determine by a single exposure the penetrability of steel to the rays furnished by this equipment and the extent to which defects could be detected, an arrangement of the type shown in Fig. 2 was employed. Using powerful intensifying screens, radiographs of steel plates were filmed at tube voltages between 500 kv. and 1,000 kv.; with a steel scale increasing in stages of 5 mm. it was simple to determine at each test voltage the thickness of steel *d* giving a film blackening *S* of 0.7 (comparison with calibrated films having this blackening value). The limiting thickness penetrated in each case was then obtained by adding the thickness of steel *D* corresponding to preliminary filtering, *viz.*, 19 mm. Exposures were made with a field 15 by 20 cm. and a constant focus-film distance of 150 cm., first without a secondary radiation filter and nextly with a preliminary lead filter 1 mm. thick. Defects and inclusions were produced artificially by placing wires of different thicknesses across the steel scale, always at the same distance of 65 mm. from the film. The detectibility of these inclusions was expressed as a percentage, *viz.*, the thickness of the wire which can just be detected on the film as a percentage of the thickness of steel penetrated.

The results of the measurements made are shown graphically in Fig. 3. The values for

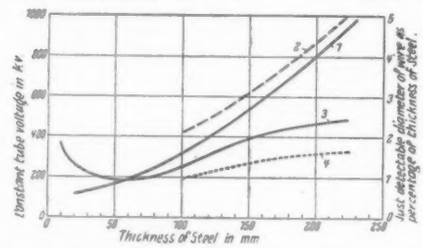


FIG. 3.—RESULTS OF STEEL THICKNESS PENETRATED AND DETECTABILITY OF DEFECTS IN SKIAGRAMS WITH TUBE VOLTAGES UP TO 1,000 KV.

the thickness of steel penetrated with tube voltages between 500 kv. and 1,000 kv. have been recalculated for a focus-film distance of 100 cm. and an exposure intensity of 30 milliamp.-min., and the curves obtained amplified by the results already available from radiating steel with voltages up to 300 kv. Curve 1 shows the results obtained without a secondary radiation filter, and curve 2 when using lead foil 1 mm. thick inserted between the material and the film. These curves show that under the conditions employed, the rays will penetrate steel up to thicknesses of about 225 mm. and produce an image on the film.

Curve 3 shows the relationship between the thickness of steel penetrated (and hence the tube voltage) and the facility with which defects and inclusions can be detected in the absence of a secondary radiation filter, and curve 4 the degree of detectability when filtering the radiation leaving the steel block through 1 mm. of lead. The percentage detectability at 1,000 kv. is thus respectively 2.4 or 1.6 per cent. of the thickness of the steel. The detectability curves given here apply strictly for a focus-film distance of 151 cm. with 10-mm. focus, as well as for a spacer-film distance of 65 mm.; hence for steel thicknesses above 65 mm., for detecting a defect within the steel mass, *i.e.*, 65 mm. from the film. According to R. Berthold, the same sharpness in image is obtained for a defect at a greater distance from the film if the tube dis-

(*Continued at foot of next column.*)

Photoelasticity and Design Problems

As satisfactory analytical solutions do not exist for the calculation of stresses in many design problems, the application of photoelasticity is being developed, this being a photographic method of showing the distribution and magnitude of stresses produced in structural and machine parts under load. Photoelastic investigations have mostly been limited to the study of stresses in two dimensions, that is, where the loads are acting in the plane of the design part. But many problems occur in three dimensions, and such types often may be handled by selecting a slice through the member for two-dimensional study. In such cases, while the results are of considerable significance, they are generally of a qualitative value in that they afford the engineer a better understanding of the problem under consideration and suggest what improvements may be made.

A recent Paper by O. J. HORGER and T. V. BUCKWALTER, published in "The Iron Age," deals only with the aspects of two-dimensional studies. A model of the design part to be studied is machined from a flat piece of some isotropic transparent material such as bakelite, Marblette, or other similar material. The model is loaded in a manner to simulate service conditions. When polarised light from a mercury-vapour lamp is passed through the stressed model, each element of the model acts as a double refracting crystal. An interference effect is produced to obtain a projected image, showing a series of black and white bands or fringes spaced one wave length of light apart. These bands indicate the magnitude and distribution of shearing stress in the model. The magnitude of the stress is proportional to the order number of the interference bands and each fringe passes through points in the model which have the same value of shearing stress. The use of such plastic models to replace actual members, which may be of steel, often leaves some question with the engineer as to the validity of the results. This feeling, however, the authors state, is not justified when it is considered that the stress distribution in simply connected bodies remains the same regardless of the elastic constants so long as the stresses are below the elastic limit.

Catalogue Received

Moisture Detection. We have received from the Colloid Equipment Company, Inc., of 50, Church Street, New York City, two leaflets which illustrate and describe the Delmhorst moisture tester. The apparatus carries a battery, the circuit of which is closed when the two or four needlelike electrodes are inserted into moisture-carrying materials. The cheapest model registers "dry, wet and very wet," but the more expensive ones are calibrated to deal with a range of 12 to 24 per cent. The most important applications of the instrument appear to be in the direction of leakage detection and ascertaining the moisture content of plaster on walls and timber. The range cited is too high for application to moulding sands, but if it could be reduced to, say, 0.5 to 8 per cent., the instrument would be welcomed by the foundry industry for testing the moisture content of mould walls.

(*Continued from previous column.*)

tance and the time of exposure are both increased; but there are various disadvantages associated with increasing distance between the tube and the test-piece, such as greater scatter radiation, while defects are more difficult to detect.

Effects of Sulphur on Properties of Electric-Furnace Cast Iron*

By FULTON HOLTBY and RALPH L. DOWDELL

Review of Previous Investigations

Sulphur in pig-iron is derived primarily from the coke and sulphur compounds of the blast-furnace burden. The foundry grade of blast-furnace pig-iron has a sulphur content of 0.02 to 0.05 per cent. Ordinarily, when metal is melted in a cupola or common fuel-fired furnace without flux, the sulphur content is increased. This increase is the result of an absorption of sulphur dioxide (SO_2) from the fuel. Moldenke[1] gives the average increase of sulphur in the iron as 0.02 per cent. with good cupola practice and as high as 0.06 per cent. with poor cupola practice. This percentage continues to increase during each remelting, resulting in a sulphur content of about 0.12 per cent. for the best machinery iron scrap available at the present time.

Present-day specifications for cast-iron limit the sulphur content to 0.10 or 0.12 per cent. These limits require that the foundrymen use more expensive low-sulphur pig-iron and less high-sulphur, low-cost scrap in their furnace charges to keep sulphur under the specified maximum limits.

Desulphurising molten cast iron in the furnace, forehearth, or ladle has become accepted practice during the past 10 years as a means of keeping sulphur down to the specified limits. Evans[2] recommended 10 lbs. of fused soda ash (commercial sodium carbonate) added to a ton of metal in the ladle to decrease the sulphur content 50 per cent. Girardet and Lelievre[3] also investigated the desulphurisation of cast iron with sodium carbonate. Bettendorf and Wark[4] recommended lime (calcium oxide) and fluorspar (calcium fluoride) as the most efficient desulphurisers. Many other investigators have condemned sulphur in amounts over 0.10 per cent. as being harmful to the properties of cast iron and have devised methods of reducing it by chemical means.

A few investigators have denied that the presence of sulphur is a source of certain trouble. Moldenke[5] stated that it was possible to make soft and machinable castings containing 0.22 per cent. sulphur with a normal silicon content. The American Society for Testing Materials[6] advanced the limit of sulphur to 0.17 per cent. about 1924 in its standard specifications for chilled car wheels. They have decreased the permissible amount present until now 0.14 per cent. is the limit. The specifications state that the minimum percentage of manganese shall not be less than three times the sulphur content.

Hurst[7] states that British foundrymen for some time have recognised that sulphur in cast iron is not necessarily harmful.

A careful survey of available literature, back to 1910, showed only one investigation where the influence of sulphur on the physical properties of cast iron had been tested under actual foundry practice. Smith and Riggan[8] concluded from two hundred series of tests on cupola cast iron that: (1) the strength and fluidity of cast iron are not affected by sulphur; (2) Brinell hardness and combined carbon increase with sulphur content; (3) machinability decreases with an increase in sulphur content; (4) the sulphur content can be decreased by manganese additions and manganese is decreased by sulphur additions; and (5) sulphur up to 0.18 per cent. has little effect on the properties of grey iron if the iron has a correct percentage of manganese.

Scope of Present Investigation

The research the authors are describing consisted in making and testing 40 casts of electric-furnace cast iron in the form of various test-bars. These bars were tested for transverse strength, deflection, tensile strength, flowability, machinability, hardness, contraction, depth of chill, chemical analysis and microstructure.

It would be impossible to investigate the effects of sulphur in all different compositions of electric-furnace iron or in any one composition poured at all possible pouring temperatures. The composition, therefore, was kept as nearly constant as possible, varying only the amounts of sulphur. The objective was to work with ordinary commercial metal and duplicate the usual pouring temperatures. The iron was heated to 1,537 deg. C. and poured at 1,426 deg. C.

In the past, foundrymen have endeavoured to keep the sulphur content in cast iron below 0.10 per cent., believing that it was the source of innumerable undesirable properties. Few investigations have been conducted to determine whether or not the effects of sulphur were as bad as is generally believed. The purpose of the investigation as discussed in this Paper is to determine the effects of sulphur on electric-furnace cast iron.

Metals Used

Metals used for furnace charges consisted of two grades of pig-iron, steel forge scrap, commercial stick iron sulphide, and granulated ferro-manganese. The chemical analyses of these raw materials are shown in Table I.

TABLE I.—*Chemical Composition of Raw Materials.*

	C. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.
Pig-iron A ..	3·97	2·96	1·12	0·013	0·13
Pig-iron B ..	3·19	2·85	0·90	0·028	0·13
Steel scrap ..	0·20	0·03	0·52	0·028	0·022
Iron sulphide	—	—	—	26–28	—
Ferro-manganese	5·00 (approx.)	—	80–85	—	—

The foundry technique used in making test-bar moulds, and melting and pouring the metal, was developed especially for this investigation to maintain, as nearly as possible, constant conditions.

Preparation of Moulds

Moulds for transverse test-bars and chill test-bars were baked moulds of core sand having the following composition by volume: 48 parts silica sand, 1 part linseed oil, and 2 parts water. When baked for 4 hrs. at 218 deg. C., the mixture showed a permeability of 85 to 95. The vertical transverse test-bar mould consists of a double mould cavity, strainer cores, and pouring basin.

Moulds for the flowability, step and contraction test-bars were made from green synthetic moulding sand on a combination jolt-squeeze moulding machine. The synthetic sand had the following composition by volume: 24 parts silica sand, ¼ parts bentonite, ¼ part cereal flour, and 1¼ parts water. When squeezed at a pressure of 70 lbs. per sq. in., the sand had a green permeability of 75 to 85 and a green compressive strength of 5 lbs. per sq. in.

Melting

An electric, rocking, indirect-arc furnace was lined with mullite bricks and, when found necessary, was patched with the same material. The furnace was cleaned of all slag, patched, and started from room temperature for each heat. The lining was preheated to 815 deg. C. before the furnace was charged. The charge, consisting of 180 lbs. of pig-iron, 20 lbs. of scrap steel and the iron sulphide additions, was placed in the hot furnace so that the sulphide sticks were protected from the arc by the pig-iron and the steel scrap. The pouring spout of the furnace was partially closed with a brick and melting was started.

Heats, of two casts each, were made from a charge of pig-iron A, steel scrap and iron sulphide. This metal was superheated to 1,537 deg. C., and half of it was poured at 1,426 deg. C. into the test-bar moulds. This portion of the heat was designated as the first cast of the heat and the test-bars poured from it were given even numbers. The second portion, or cast, from each heat was poured at 1,426 deg. C. from the same metal after a ferro-manganese addition had been made, and the metal heated to 1,537 deg. C. The test-bars made from the second cast of each heat were given odd numbers, one higher in number than the first cast of the heat. The cast numbers of these heats are 10 through 29 and are called series A.

The furnace input for this series of heats was 90 kw. per hr., requiring a total of 92 kw.-hrs. to heat the metal to 1,537 deg. C. for the first cast. Melting time averaged 1 hr. 8 mins. The second cast required 10 kw.-hrs. additional input.

Ten heats of two casts each were made from a charge of pig-iron B, steel scrap and iron sulphide, using a faster melting rate. These heats were duplicates of series A, except for melting time. The cast numbers of these heats are 30 through 49 and are called series B.

The main difference between series A and B was that series A casts had a higher initial content of manganese and a melting time of 12 mins. longer than series B.

The furnace input for this series of heats was 110 kw. per hr., requiring 88 kw.-hrs. to bring the metal up to 1,537 deg. C. for the first cast. The melting time averaged 55 mins. The second cast required 8 kw.-hrs. additional input. The rocking cycle of the furnace during melting was 2 notches at 40-kw. input, 4 notches at 50-kw. input, and 8 notches at 60-kw. input. The furnace was shut off after 92-kw. input for series A, and 88-kw. input for series B, and the temperature of the metal was measured. If the superheat temperature was not up to 1,537 deg. C., melting was continued until this temperature was reached. Several heats were overheated and the excess superheat temperature was plus or minus 10 deg. C.

Temperature Measurements

Superheat and pouring temperatures of the metal were measured with a calibrated tungsten-graphite thermocouple. This thermocouple was developed and built after serious difficulties were encountered in trying to use a platinum-platinum/10 per cent. rhodium couple and an optical pyrometer. Nine preliminary casts were discarded because of errors in optical pyrometer readings caused by smoke and fumes, and because of failures in obtaining a fast, accurate temperature reading with the platinum-platinum/10 per cent. rhodium couple.

The tungsten-graphite couple was checked for errors in calibration after every 40 immersions or 4 casts. The construction and method of

* Extracted from a Paper read before the Chicago Meeting of the American Foundrymen's Association. The authors are Instructor in Foundry Practice and Professor of Metallography, respectively, at the University of Minnesota, Minneapolis, Minn.

calibration is shown in a Paper by one of the authors.[9]

Pouring

Molten iron was poured from the furnace into a small 25-lb. preheated hand ladle. The tungsten-graphite thermocouple was immersed in the metal while the ladle and metal were being weighed. The metal was slowly stirred with the thermocouple to obtain a uniform temperature in the metal. When the iron reached a temperature of 1,426 deg. C., it was poured into a test-bar mould. The ladle was re-weighed after pouring to determine the weight of the metal removed from the furnace. The hand ladle was refilled and the procedure repeated. The order of pouring the test-bar moulds was: (1) Transverse test-bars *a* and *b*, (2) flowability test-bar and chill test-bar, (3) step test-bar and contraction test-bar, and (4) transverse test-bars *c* and *d*. The weight of the metal removed from the furnace was determined, and the remaining metal was poured into pigs until only 100 lbs. remained in the furnace.

The second part, or cast, of the heat consisted of making an addition of ferro-manganese to the remaining molten metal and reheating to 1,537 deg. C. This required an additional 10-kw. input, taking 8 mins. time. The metal was poured in the same manner and at the same temperature as the first 100-lb. cast. The test-bars were left in their moulds until they had reached room temperature. The bars then were removed from the moulds and labelled with zinc tags, wired to the casting.

Determination of Properties

Test-bar castings were tested for transverse strength, tensile strength, flowability, depth of chill, contraction and machinability.

Transverse Test

Four transverse test-bars, 21 in. long and of 1.20 in. dia., were made from each cast. These bars were broken on 18-in. supports with a hand-operated transverse machine. Deflection of the specimen was read at 1,500-lb. load and at the breaking load. The diameter of the bar at the break was measured, and if found to be other than 1.20 in., a correction factor[10] was applied to the breaking load.

Tensile Test

A tensile test-bar was machined from the lower half of three transverse test-bars from each cast. The standard A.S.T.M. dimensions[10] were used with a polished neck diameter of 0.800 in. The tensile bars were tested in a 20-ton capacity tensile machine using a pulling speed of 0.05 in. per min.

Flowability Test

The flowability test-bar[11] was measured when removed from the mould. The 2-in. reference marks along the upper surface of the bar were counted and the number of inches the metal had run in the mould was recorded.

Chill Test

The chill test-bar was broken in the centre while held in a special cast-iron breaking block. The depth of chill at points A and E was measured and the appearance of the fracture at points B, C and D was recorded.

Contraction Test

The gauge bar was part of the mould. The molten metal, upon solidifying, took the shape of the mould cavity, which was 1 in. square by 12 in. long. The difference in length of the bar at room temperature and at freezing temperature was measured and recorded in 64ths of an inch contraction per foot length.

Machinability Test

Machinability was determined by measuring the time required for a drill, driven at a constant speed under a constant load, to penetrate the metal a definite depth. The step test-bar used for the machinability test is 2 in. wide and increased by steps from $\frac{1}{4}$ to 2 in. deep. This bar was held in a vice on the table of a 14-in. drill press. The $\frac{1}{2}$-in. high-speed drill was driven at 474 r.p.m. by the V-belt drive. A constant 160-lb. load was applied to the drill by means of a weight hung on a $\frac{1}{4}$-in. steel tiller rope which passed over and was attached to a sheave pulley. The casting was spot drilled centrally in each step with a used drill to remove any sand or scale. Holes were then drilled at these points using a freshly-sharpened drill for each hole. Time readings were taken with a stop watch for each $\frac{1}{4}$ in. of penetration in the 2-in. and 1-in. sections, for each $\frac{1}{8}$ in. of penetration in the $\frac{1}{2}$-in. section, and for each $\frac{1}{16}$ in. of penetration in the $\frac{1}{4}$-in. section. The $\frac{1}{8}$-in. section was tested only as machinable or not machinable. The depth of penetration was measured on the graduated spindle of the drill press. A second run was made on the 2-in. and 1-in. sections, using the same respective drill to check on the wearing of the cutting edge. Each hole, except in the duplicate runs, was made with a drill sharpened in a precision drill-grinding machine.

Chemical Analysis

The determinations of the chemical analyses were made by the standard methods; however, sulphur was determined gravimetrically.

Recording of Results

The physical properties, obtained from the test specimens, were entered on individual report sheets and the resulting properties calculated. The chemical analyses for the casts of series A are shown in Table II, and those of series B in Table III. The properties obtained were plotted.

Results Obtained

The test results of the B series show more uniformity than the A series. This was due to the faster melting rate used in the B series and the experience and data obtained from the A series which were used in planning the later casts. The chemical analyses of the casts from the first part of each heat showed a definite decrease in manganese content as the sulphur content was increased. This decrease in manganese was more rapid as the sulphur content was increased beyond 0.18 per cent.

TABLE II.—*Chemical Analysis (Per cent. by Weight), Series A.*

Cast no.	C.	Si.	Mn.	S.	P.
10 ..	3·56	2·49	0·86	0·228	0·13
11 ..	3·56	2·46	1·23	0·161	0·12
12 ..	3·53	2·45	0·77	0·331	0·13
13 ..	3·54	2·40	1·56	0·152	0·13
14 ..	3·48	2·52	0·67	0·349	0·13
15 ..	3·40	2·57	1·45	0·163	0·13
16 ..	3·45	2·65	0·83	0·165	0·13
17 ..	3·51	2·61	1·48	0·086	0·14
18 ..	3·46	2·58	1·06	0·017	0·13
19 ..	3·41	2·64	1·57	0·014	0·13
20 ..	3·48	2·61	0·98	0·171	0·13
21 ..	3·53	2·56	1·63	0·144	0·12
22 ..	3·49	2·44	0·96	0·198	0·13
23 ..	3·48	2·55	1·69	0·111	0·11
24 ..	3·54	2·51	1·04	0·057	0·12
25 ..	3·52	2·57	1·58	0·047	0·15
26 ..	3·49	2·50	1·00	0·068	0·11
27 ..	3·45	2·54	1·68	0·056	0·12
28 ..	3·49	2·53	0·98	0·153	0·12
29 ..	3·42	2·57	1·56	0·147	0·12

Manganese in cast iron is present as an oxide, as iron-manganese carbide ($[FeMn]_3C$), and as manganese sulphide (MnS), or manganese sulphide-iron sulphide (MnS.FeS). With the large amount of silicon and carbon present, it is doubtful whether much of the manganese was lost by oxidation. The manganese, which forms manganese carbide by combination with carbon, is not lost and is part of the reported manganese. The manganese which combines with sulphur forms manganese sulphide from the reaction Mn + S = MnS requiring 1.73 parts by weight of manganese and 1 part by weight of sulphur to form 2.73 parts by weight of manganese sulphide. If the sulphur is present as iron sulphide, the manganese forms manganese sulphide from the reaction FeS + Mn = MnS + Fe, which according to Herty and True[12] is reversible.

This manganese sulphide, according to Rohl,[13] has a melting point of about 1,621 deg. C., and hence is a solid at the temperatures used in this investigation. Moldenke[5] reports the specific gravity of manganese sulphide to be about 3.55 as compared with 7.20 for molten iron. As this solid manganese sulphide, having only half the specific gravity of iron, is formed, it will tend to float to the surface of the metal and be skimmed off as slag. This decrease in manganese content with an increase in sulphur content agrees with the results reported by Smith and Riggan.[8]

TABLE III.—*Chemical Analysis (Per cent. by Weight), Series B.*

Cast no.	C.	Si.	Mn.	S.	P.
30 ..	3·56	2·77	0·85	0·097	0·12
31 ..	3·51	2·73	0·89	0·095	0·11
32 ..	3·55	2·62	0·85	0·172	0·12
33 ..	3·53	2·64	1·01	0·170	0·12
34 ..	3·57	2·61	0·81	0·281	0·13
35 ..	3·55	2·68	1·09	0·241	0·13
36 ..	3·55	2·68	0·80	0·295	0·11
37 ..	3·52	2·67	0·97	0·277	0·12
38 ..	3·45	2·65	0·85	0·027	0·12
39 ..	3·37	2·70	0·91	0·028	0·13
40 ..	3·44	2·68	0·70	0·500	0·11
41 ..	3·52	2·72	0·74	0·332	0·11
42 ..	3·41	2·67	0·73	0·360	0·11
43 ..	3·46	2·70	0·81	0·289	0·12
44 ..	3·57	2·68	0·87	0·140	0·12
45 ..	3·42	2·69	0·92	0·139	0·12
46 ..	3·51	2·66	0·82	0·110	0·12
47 ..	3·52	2·65	0·90	0·109	0·12
48 ..	3·57	2·61	0·66	0·207	0·12
49 ..	3·47	2·63	0·94	0·203	0·12

The chemical analyses of the casts from the second part of each heat showed a definite drop in sulphur content as the manganese increased. This decrease in sulphur content was proportionally greater in the heats that were superheated above 1,537 deg. C. and in the heats where the melting time was long. These results prove that manganese is a desulphuriser in electric-furnace cast iron. This desulphurising action of manganese limited the amount of sulphur which remained in the second part of each heat. The second casts of the heats in series B were heated more rapidly and for a shorter length of time than those in series A and had a lower manganese content. Hence, a sulphur content of 0.332 per cent. was retained in series B as compared with 0.163 per cent. retained in series A. This does not agree with the results obtained by Shaw,[14] who believes manganese cannot lower the sulphur content under actual foundry conditions.

(To be continued.)

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Manganese Losses in Open-Hearth Practice*

SUBSTANTIAL RECOVERY AFTER MELTING

(*Continued from page* 178.)

The two examples which have been quoted show that by adopting suitable melting conditions the Mn factor can be raised to nearly 60 per cent., while the end product also has a satisfactory degree of purity. Hence if the initial charge contains less than 1 per cent. Mn, still enough Mn is retained in the charge at the end to make the subsequent addition of ferro-manganese to finish off the melt superfluous. This result confirms that already arrived at by Bardenheuer and Thanheiser, which showed that with less than 1 per cent. Mn in the charge the resulting steel is quite free from red shortness and contains sufficient Mn. The present experiments also show that the procedure adopted, which dispenses entirely with ferro-manganese for final deoxidation, can be employed on commercial melts in the 100-ton furnace.

In addition to saving ferro-manganese, which in the case of the German steel industry is a very important consideration as the raw materials required have to be imported from abroad, this process has the further advantage that the steel is protected against contamination by gases and oxides introduced by the subsequent additions made. Bardenheuer and Thanheiser have, indeed, shown that these additions are a serious source of impurities in the finished product, especially as they are brought to react at a time when the charge is no longer boiling.

If, in contradistinction to this procedure, the steel is melted under conditions in which a proportional amount of ferro-manganese has still to be added to convert higher quantities of ferrous oxide to manganous oxide after the decarburising period, comparatively large quantities of manganous oxide must be present in the finished steel. The basic manganous oxide actively attacks the high-silica refractories, causing the formation of a low-viscosity Mn silicate which is enclosed as droplets in the cast ingot and introduces defects in the final material; these defects are usually described as silicate or sand inclusions.

Oxygen Concentration

According to Bardenheuer and Thanheiser, manganese has to maintain the steel bath low in oxygen only towards the end of the decarburisation period, since before this point is reached the much more reactive carbon will determine the oxygen concentration. It does not, therefore, appear economical to have large quantities of manganese present in the charge at the very outset, for the greater part of the Mn, which has passed into the slag during melting, must then be reduced again and induced to pass into the molten metal. But this transfer is definitely limited, since, according to the present experimental data, only about 15 per cent. of the total initial Mn in the charge is again recovered from the slag by reduction. A higher initial content of Mn in the charge will thus always result in an increased loss of the metal, even when the maximum quantity is recovered by slag reduction. It is, in consequence, far more important to melt down the charge with a sufficient provision of carbon and to keep the oxygen value of the charge as low as possible by prolonged and active boiling. If the reactivity of the carbon is maintained at a high level by employing a high temperature and boiling is not carried to finality by conserving the oxygen supply, the charge at the end of decarburisation will contain so much manganese, even if only a moderate amount of Mn is initially present in the charge, that this will ensure a very low content of ferrous oxide in the melt and make the addition of extra ferro-manganese for this purpose no longer necessary. To achieve a product low in oxygen and at the same time realise a satisfactory Mn-recovery factor, it is evidently important to melt down the charge rapidly, so that at the end of decarburisation the charge is at the requisite temperature for teeming, and does not have to be further heated in the furnace, which would further reduce the carbon content as well as the Mn content, and moreover simultaneously increase the oxygen value. The carbon value required for melting down the charge is determined, on the one hand, by the refining action of the furnace and, on the other, by its thermal efficiency.

Experiments have indicated that a high manganese-recovery factor can hardly be realised when the charge is melted too slowly. After working, one of these charges contained only 0.24 per cent. C in the melt and 20.44 per cent. Fe in the slag; the higher degree of oxidation of the iron also caused an increase in the amount of slag formed (7.2 per cent.). In addition, the slag was very basic already shortly after melting, the degree of basicity 100 $CaO/(CaO + SiO_2)$ being 76.5. In spite of high ferrous-oxide content of the slag, agitated boiling and hence a reduction of manganese from the slag was out of the question. The manganese-recovery factor was only 33.1 per cent.

Slag Characteristics

The quantity of slag obtained is determined both by the chemical composition of the charge and the amounts of lime and ore which have to be added, as well as by the melting conditions. Thus a high P content in the charge demands a corresponding increase in the lime added and increases the quantity of slag formed. A higher P content in the converter metal, which favours a higher initial Mn value, results in neither a higher Mn value nor a sufficiently low P content in the final product. It is thus useless to use converter metal with a high P content, with the object of increasing the manganese added to the open-hearth, since the greater amounts of slag which are then required to remove the phosphorus mean the loss of some of the Mn. On the other hand, the melter is unable to tap the metal exactly at the moment the manganese is at a maximum, with the result that the converter metal may readily be high in phosphorus and low in manganese.

In addition to the absolute amount of slag, the slagging reaction itself also has an important bearing on the reduction of manganese from the slag. If the latter has too high a basicity, mass exchange between the melt and the slag is rendered more difficult, and as already shown by R. Back, this adversely affects the manganese-recovery factor. The suggestion of initially increasing the basicity of the slag when both the melt and the slag are at a low temperature, by the addition of excess lime so that its reactivity is *a priori* very low, cannot therefore be recommended. Since, as the temperature of the melt progressively rises, increasing quantities of lime enter solution, the slag may eventually become entirely non-reactive and labile. Should the viscosity of the slag be too high, particles of iron projected during the boil will be retained in the slag and oxidised there. If a sample of steel is taken from a melt with a high-basic slag, many little globules of iron are found in the slag adhering to the spoon.

The conditions obtaining during melting when using a slag of this composition have been described by Bardenheuer and Thanheiser, where two slags were run, the basicity of the second slag increasing from 75.4 to 82.5. Although the total content of ferrous oxide in the slag exceeded 26 per cent., the rate of decarburisation in the last two hours was only 0.05 per cent. C per hr., indicating that the slag was extremely inert.

A series of experimental melts examined by the authors showed that, if the slag is too basic, no appreciable reduction of manganese is obtained, even if the carbon content is maintained at the requisite level. The recovery of manganese was very unsatisfactory in a melt where, apart from the slag having a basicity as high as 80 per cent., melting was too slow. The high Fe content of the slag raised the slag yield to 7.2 per cent., in spite of the fact that only moderate quantities of lime were added. On the other hand, very reactive slags of low basicity, such as those desirable for obtaining a high Mn recovery, result in very unfavourable dephosphorisation. The more active the reaction between the charge carbon and the slag, the more effective will be the reduction of both phosphoric acid and manganous oxide. In view of the high P content of the charge, as frequently found on using metal from the basic converter, slags should be avoided which have a basicity lower than 65. The intensity of phosphorus reduction, accompanying active reduction of Mn, was established by an experimental melt using a slag with a basicity which barely exceeded 65 and which therefore contained no free lime. At a point when the melt still contained 0.21 per cent. C, 16.7 per cent. of the Mn present had been recovered from the slag and passed back to the melt; at the same time the P content of the charge increased from 0.048 per cent. to 0.060 per cent. It is apparent, therefore, that in order to realise maximum recovery of manganese, dephosphorisation must be given special consideration when the charge contains much P.

The quantity of slag formed, and hence the degree of recovery of Mn, is also affected by the refining action of the furnace. With the same content of lime, a fixed furnace with low refining gave less slag than a tilting furnace with more refining, since in the latter the slag contained nearly throughout more metallic oxides and must also take up the larger quantities of silica and phosphoric acid conditioned by the greater amount of converter metal required. An alteration of the ports of the stationary furnace allowed the quantity of stahleisen to be reduced by from 10 to 15 per cent. as compared with earlier procedure, and this in its turn reduced the amount of slag formed as well as the amount of manganese to be added initially in the charge, without however affecting the recovery of manganese. On comparing the first four experimental melts following the old procedure with the next five melts in the same furnace using the new procedure, it is found that the yield of slag from 100-ton charges dropped from 10.64 tons, *i.e.*, 10 per cent., to 4.54 tons, *i.e.*, 4.2 per cent., or by roughly 42 per cent. The amount of iron in the slag had thus fallen from 1,536 kgs. (1.44 per cent.) to 523 kgs. (0.47 per cent.), and the proportion of manganese in the slag from 802 kgs. (0.75 per cent.) to 453 kgs. (0.42 per cent.) per melt. Hence by reducing the slag yield, the iron loss declined by 0.97 per cent. and the Mn

* From Report No. 366 of the Steelworks Committee of the Verein deutscher Eisenhüttenleute, by P. Bardenheuer and G. Henke, and published in "Stahl und Eisen."

loss by 0.33 per cent., referred to the initial quantities in the charge. With a total of 100,000 tons of steel these reductions represent a saving of 970 tons of iron and 330 tons of manganese. Even if 90 per cent. of the iron and 50 per cent. of the Mn in the open-hearth slag are recovered in the blast furnace, the irrecoverable losses in the blast-furnace slag for a total output of 100,000 tons have in the past amounted to about 100 tons of iron and 165 tons of Mn as compared with the modified procedure.

Oxidation Losses in Pouring

Experiments indicate that, under suitable melting conditions, it is sufficient to have 0.8 to 1 per cent. of Mn in the charge to ensure a steel containing 0.4 to 0.5 per cent. Mn and to dispense with the final addition of ferro-manganese. Retaining the same proportion of Mn in the final product, the initial Mn in the charge can be still further reduced provided Mn losses

TABLE IV.—*Carbon and Manganese Losses with Standard Method of Pouring.*

Test No.	Sample *	Composition of steel C %	Composition of steel Mn %	Additions in ladle kg.	Mn losses %
14	1	0.19	0.57	5 Al	
	2	0.11	0.45		21
15	1	0.16	0.52	5 Al	
	2	0.12	0.43		17
16	1	0.14	0.50	8 Al	
	2	0.08	0.39		22
17	1	0.13	0.51	6 Al	
	2	0.08	0.4[illegible]		20
18	1	0.13	0.39	10 Al	
	2	0.07	0.30		23
19	1	0.16	0.49	8 Al	
	2	0.10	0.41		16
20	1	0.13	0.51	8 Al	
	2	0.09	0.41		20
21	1	0.08	0.37	12 Al	
	2	0.07	0.30	70 Coal	19
22	1	0.11	0.33	10 Al	
	2	0.07	0.26	10 Coal	21
23	1	0.08	0.29	50 Coal	
	2	0.08	0.40	10 Al	
				500 Fe-Mn†	27
24	1	0.08	0.29	60 Coal	
	2	0.08	0.32	10 Al	
				300 Fe-Mn†	27
25	1	0.10	0.34	50 Coal	
	2	0.08	0.36	8 Al	
				300 Fe-Mn†	28
26	1	0.13	0.43	140 Fe-Si‡	
	2	0.10	0.33	115 Al	23
27	1	0.10	0.49	140 Fe-Si‡	
	2	0.09	0.39	115 Al	20
28	1	0.10	0.47	140 Fe-Si‡	
	2	0.09	0.38	115 Al	19

* 1 = Furnace sample, 2 = Pitside sample.
† 50% Mn. ‡ 90% Si.

can be reduced, or eliminated altogether, on tapping or transferring the metal. During transfer the steel is oxidised by atmospheric oxygen, which reduces the concentration of those metals which have a greater affinity for oxygen than iron, *e.g.*, carbon, silicon and manganese. Table IV shows that the Mn and C losses with 100-ton melts are very considerable, while with alloy steels the loss of the more costly alloying elements is greater still. Since these losses are determined mainly by the tapping and pouring conditions employed, they make it difficult to retain a specific composition of steel. During tapping, Mn losses may become so great that, in spite of a satisfactory Mn recovery in the furnace, the Mn content of the final product is still too low, so that ferro-manganese must be added to compensate for the pouring losses.

Various means have been employed in the past to counteract these oxidation losses, such as the production of a reducing atmosphere with tar, oil and other materials over the surface of the metal, or the addition of neutral or reducing agents which cover the molten steel with a protective film. The success achieved by these means has, however, only been conditional. An investigation of the causes of these oxidation losses indicated that, in the main, they were due to the entrainment of large volumes of air by the jet and the formation of strong eddies in the ladle facilitating contact between steel and oxygen. Those air bubbles which are dragged far down into the mass of steel have the same refining action as oxygen in air converting, while oxidation losses will be the greater the deeper the jet of steel penetrates the mass. Simple hydrodynamical studies indicated how this close access of oxygen could be prevented

TABLE V.—*Carbon and Manganese Losses in New Pouring Method.*

Test No.	Sample *	Composition of steel C %	Composition of steel Mn %	Additions to ladle kg.	Mn losses %
29	1	0.13	0.40	8 Al	
	2	0.09	0.39		2.5
30	1	0.14	0.53	8 Al	
	2	0.10	0.49		7.5
31	1	0.11	0.34	10 Al	
	2	0.10	0.32		6
32	1	0.09	0.38	8 Al	
	2	0.08	0.35		8
33	1	0.13	0.42	8 Al	
	2	0.09	0.39		7
34	1	0.11	0.42	10 Al	
	2	0.09	0.38		9.5
35	1	0.13	0.37	8 Al	
	2	0.09	0.35		5.5
36	1	0.09	0.34	8 Al	
	2	0.09	0.31		9
37	1	0.09	0.41	10 Al	
	2	0.08	0.37		10
38	1	0.07	0.33	140 Fe-Si†	
	2	0.07	0.32	115 Al	3
39	1	0.09	0.36	140 Fe-Si†	
	2	0.08	0.34	115 Al	5.5
40	1	0.09	0.39	140 Fe-Si†	
	2	0.09	0.39	115 Al	0
41	1	0.09	0.32	85 Mn to 108 t	
	2	0.08	0.36	8 Al	10
42	1	0.10	0.30	80 Mn to 115 t	
	2	0.07	0.33		11
43	1	0.09	0.34	60 Coal	
	2	0.09	0.32	12 Ca-Si	6
44	1	0.09	0.34	70 Coal	
	2	0.09	0.33	12 Ca-Si	3
45	1	0.10	0.35	50 Mn to 108 t	
	2	0.10	0.39	50 Coal 12 Ca-Si	2.5
46	1	0.07	0.28	100 Mn to 107 t	
	2	0.11	0.37	60 Coal 12 Ca-Si	0
47	1	0.08	0.30	75 Mn to 108 t	
	2	0.10	0.36	60 Coal 12 Ca-Si	4
48	1	0.52	0.71	340 Fe-Si†	
	2	0.51	0.71	28 Al	0
49	1	0.69	0.86	340 Fe-Si†	
	2	0.68	0.85	28 Al	1
50	1	0.58	0.60	340 Fe-Si†	
	2	0.57	0.59	28 Al	2

* 1 = Furnace sample, 2 = Pitside sample.
† 90% Si.

and led to a modification of the pouring arrangements. The ladle was raised to be almost horizontal in line with the lip of the spout, as shown in Fig. 5a, so that the metal could flow into the ladle with little change of direction and without breaking up the stream into individual jets. As the metal collects in the ladle, the latter is slowly lowered (Fig. 5b), so that the minimum gap is retained between the end of the spout and the level of molten steel in the ladle. This avoids the entrainment of air and the formation of powerful eddy flow in the steel, thus reducing to a minimum loss due to the oxidation of carbon and manganese. This method of tapping also prevents the stopper rod and nozzle from cracking owing to an excessive rate of heating.

The net effect of this modified method of tapping on the carbon and manganese losses is shown by the results of experiments given in Table V. These indicate that the Mn losses are reduced to a fraction of those sustained hitherto, and also that there is a marked drop in the carbon losses, so that a specified steel composition can be maintained with greater ease. The Mn loss with ferro-manganese added to the teeming ladle is naturally somewhat greater as the alloy is already oxidised at the surface (experiments 41 and 42). Those melts to which

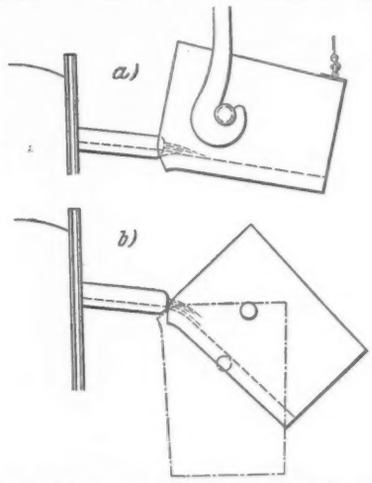


FIG. 5.—METHOD OF TAPPING AN OPEN-HEARTH FURNACE TO AVOID OXIDATION LOSSES.

carbon and ferro-manganese were added in the ladle showed only small losses. It was found advisable to add the carbon before pouring into the ladle, so that these portions of steel running out first had a high carbon content, and the carbon is mainly responsible for combining with atmospheric oxygen. For these reasons the hard-steel charges in experiments in 48 to 50 showed low Mn losses.

Alterations in Income Tax Procedure

(*Continued from page* 186.)

The position of the individual taxpayer now is that the standard rate (8s. 6d.) will not be paid—if income is all earned—unless the total income in the case of a single person exceeds £318; in the case of a man and wife £402; of a man, wife and one child £462; and of a man, wife and two children £522, the appropriate allowances (*i.e.*, one-sixth earned income, from one-fifth; personal £100; wife £70 from £80: each child £50 from £60) leaving a taxable income of £165 in each case. Therefore, with total incomes as above, only the reduced rate of 5s. will apply, so that the total tax payable in each case would be £41 5s. (£165 at 5s.). Furthermore, no person is within the taxable field if the total income (investment or earned) does not exceed £120; in the case of all earned income, a man with wife does not pay tax unless the total income exceeds £204; a man with wife and one child £264, and a man with wife and two children £324, the allowances being an effective set-off against these amounts.

Allowances for life assurance premiums are restricted, and apply after income has been declared, but the working of this provision ordinarily meant—the allowances being worked out at one half of the standard rate—that where the tax poundage has been increased, so the actual amount of the allowance has been more. This new Act, however, provides that where the standard rate is more than 7s. (as now) the rebate is only to be given as if the standard rate is 7s.; thus the allowance is ordinarily fixed at 3s. 6d. in the pound, as regards amount of income used for the premium payment.

For High Quality Castings

The increasing demand for high-strength close-grained iron castings calls for improved metal. In comparison with the accepted standards of the past, the modern high quality casting requires lower total carbon and phosphorus, with a closer range in silicon. The Ironfounder can now meet this demand at a reasonable cost by the use of Stanton-Dale Refined Pig Iron.

Stanton-Dale is a pig iron of low total carbon, the graphitic carbon being uniformly distributed and of fine curly-flake formation. The close structure ensures remarkably high strength with good machineability, and Tensiles of 16 to 20 tons can readily be obtained when a proportion of Stanton-Dale Iron is introduced.

The use of this iron avoids the irregularities in structure which are sometimes observed when steel scrap has formed part of the charge.

The correct grade of Stanton-Dale Iron to use depends on the type and class of castings to be made. The Stanton Technical Service is available to advise on suitable mixtures.

Total Carbon from 2.6 per cent. upwards. *Analysis to individual specification as required.*

STANTON-DALE
REFINED PIG IRON

The Stanton Ironworks Company Limited, Near Nottingham

***The Largest** Producers of Foundry Pig Iron (for Sale) in Great Britain*

Eliminating Gas Losses on Reversing Open-Hearth Furnaces

On reversing an open-hearth furnace, a certain amount of gas is always lost, particularly when the gas-side of the furnace is equipped with a standard form of mushroom valve. This gas loss is made up of two components, of which the first is determined by the time taken to change over the valve and the differential pressure subsisting between the gas main and the stack. In the case of a 50-ton furnace of ample dimensions with a standard consumption of 3,500 cub. m. of crude-lignite producer gas per hr., measured at N.T.P., this loss may amount to 12.5 cub. m. on each reversal, with a total time of reversing of about 8 secs. and a pressure difference during reversal of 74 mm. of water. The gas pressure is automatically controlled to 38 mm. of water, while the gas delivery to the stack rises to about 1.8 times the normal quantity during reversal. It is evident that with 160 reversals per day this loss, which may be termed the closed-circuit losses, may amount to as much as 2.5 per cent. of the total gas consumption.

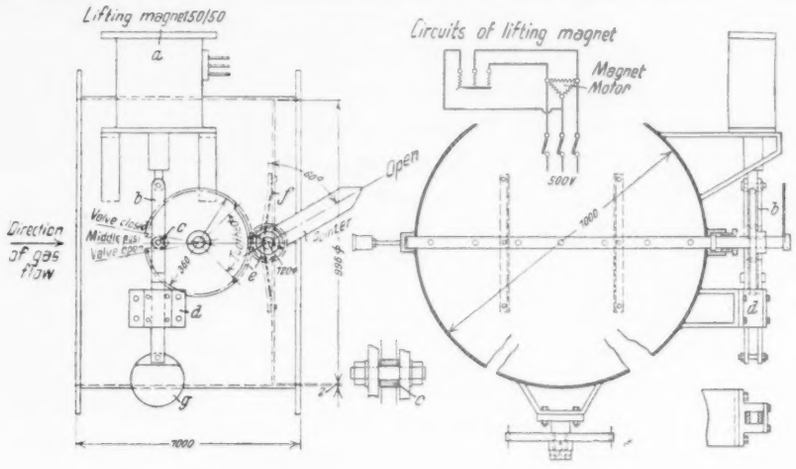


FIG. 1.—GAS ECONOMY ARRANGEMENT FOR OPEN-HEARTH FURNACES.

The component due to design cannot as a rule be eliminated, for its magnitude is determined by the volume of the spaces between the downshaft of the gas valve and the gas-flue opening, as well as by the temperature conditions prevailing in these spaces at the beginning of the reversal operation. In the case of the furnace examined the design loss was about 23 cub. m. at N.T.P. per reversal and hence about double the closed-circuit losses. Compared to the design losses, the closed-circuit losses can be almost entirely eliminated by simple means, provided the open-hearth is not heated with gas liable to form incrustations, such as coke-oven and mixed gases or producer gas made from raw lignite or raw lignite briquettes. These losses may in fact be saved by cutting off the gas supply to the furnace completely and automatically during the period of reversal. To achieve this, a throttle valve is inserted in the gas main as close as possible to the mushroom valve, as indicated in Fig. 1, and the throttle kept open normally but closed during changing over. A powerful electro-magnet is used for operating the flap, being connected in parallel to the driving motor for the mushroom valve. A system of gears is located between the magnet and the flap shaft for transmission and also for adjustment of the flap travel.

When on starting a reversal the driving motor is started up, the magnet *a* raises drawbar *b* with counterweight *g* and moves the flap into the closed position through roller *c* and gearing *e*. When the cut-out interrupts the driving current at the end of the reversal period, current is removed from the magnet and the flap returns to the open position under the action of the counterweight. It takes 0.7 sec. to open and close the flap. The gas leakage through the flap valve can be reduced to a minimum by a close machining of the contacting surfaces of the valve housing and flap cheeks. A gas-control gear of this type has been installed on a furnace for two years, reports O. PSZCZOLKA in the brief description given in "Stahl und Eisen," and it has operated satisfactorily. Installation costs are small and the equipment requires no maintenance.

(*Continued from third column.*)

(number of reagents large). Appearance: Colour, patina, reflecting power, etc. Response to heat-treatment. Forgeability, hot- and cold-working properties. Cost of raw materials and processing. Fatigue endurance, using both polished and notched specimens determining damage line, at ordinary temperature, and at elevated temperatures, also under corrosion conditions. Properties at high and low temperatures. Wear resistance. Impact toughness, using specimens of different width and different notches. Machinability.

From this list and from the number of alloys that may be studied, it is obvious that only a beginning has been made in the study of possible alloys. Research work in physical metallurgy should not be directed to the simple job of examining all of the possible binary systems and making tests on individual alloys as outlined, but rather to the selection of systems and particular alloys on the basis of the fundamental available information and studying them to find out their valuable properties and possible industrial applications. Another method of approach is to strive for a complete understanding of the requirements of metals and alloys for particular applications and then to give consideration to the metals and alloy systems, using again the best fundamental information available to select the most promising materials for study. Such a procedure is most likely to find new metals and alloys for particular industrial applications and to give the best return.

Possible Alloy Systems

BINARY, TERNARY AND QUATERNARY

Surveying the nature of and progress in physical metallurgy in the first Priestley lecture given at Pennsylvania State College, and reprinted in "Mining and Metallurgy," DR. O. E. HARDER, assistant director, Battelle Memorial Institute, refers to the number of possible alloy systems. Assuming that forty metals are available for the production of alloys, and making all the possible combinations of these metals into binary, ternary, and quaternary alloys, that is, alloys containing two, three, and four metals respectively, the possible number of alloy systems is as follows: Binary, 780; ternary, 9,880; quaternary, 91,390; total, 102,050.

In the latest comprehensive report on binary alloys, by Hansen, between 800 and 900 binary systems are included, some of them including non-metals, more than half of which have been incompletely studied. Some fifty to one hundred ternary systems have been studied, but many of these incompletely. Only one quaternary system, Al-Cu-Si-Mg, has been studied comprehensively. All the other systems are yet to be studied, and afford possibilities for future development. Research on these alloy systems with a view to their industrial and scientific importance is likely to be most fruitful, states the author. Many alloys containing four and five important alloying elements are now being used, as, for example, high-speed steel containing iron, carbon, chromium, tungsten, and possibly vanadium, molybdenum, cobalt, and uranium. Dental golds may contain gold, silver, copper, platinum, palladium, nickel, and zinc.

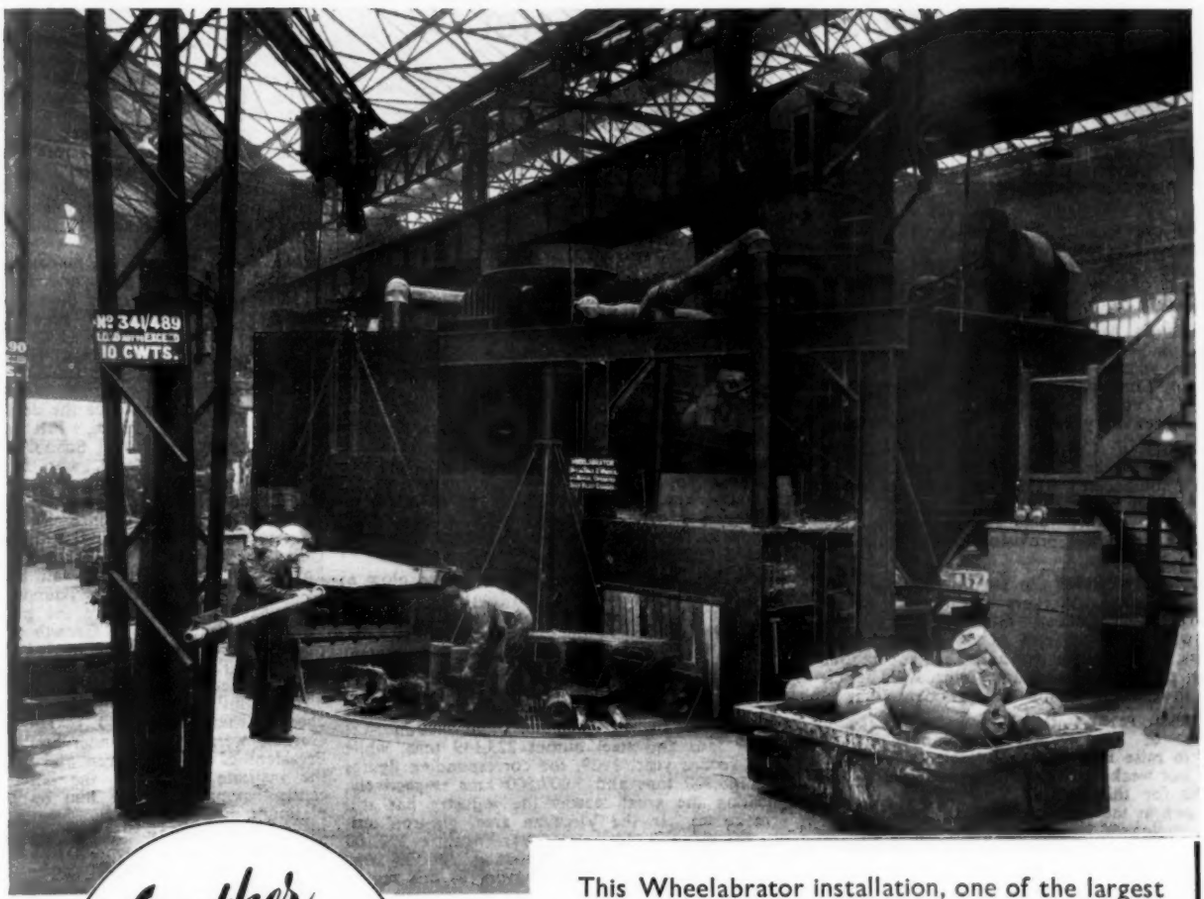
Calculating the number of possible alloys and using as the variable a change of 10 per cent. in composition, one then gets a much larger number of alloys, comparing favourably with the total number of chemical compounds developed by organic chemists. The number of alloys then becomes as follows: Binary alloys, 7,020; ternary alloys, 355,680; quaternary alloys, 7,676,760; total, 8,039,460. Comparing this total number of over 8,000,000 possible alloys with the number that have been studied, indicates how relatively little has been done and what a great unexplored field of metallurgical research remains.

Properties of Specific Compositions

Not only have the alloy systems been incompletely investigated from the standpoint of their constitution diagrams, but there is an even greater lack of information about the properties of alloys of given compositions within these systems. In the previous tabulation the possible number of alloys was on the basis of 10 per cent. variations in composition which gives an impressive number of alloys. If now one considers the work necessary to give a fairly complete knowledge of a single alloy and multiplies that by the number of alloys, one can guess how much work remains to be done. The following incomplete outline indicates the work that may be necessary in studying a single alloy.

Outline of Study of an Alloy.—Preparation of alloy. Thermal analysis for the determination of liquidus and solidus lines; transformations in the solid state. Macro- and microscopic-examination. Chemical analysis. Physical properties, covering hardness and density. Mechanical properties: Tensile strength, elastic limit, elongation, reduction of area, modulus of elasticity, creep resistance. Electrical properties: resistance, conductivity, coefficient of electrical conductivity. Magnetic properties. Thermal properties: Thermal conductivity, coefficient of expansion. X-ray metallography, with determination of crystal lattice. Corrosion resistance

(*Continued at foot of previous column.*)



Another Wheelabrator Triumph!

This Wheelabrator installation, one of the largest of its kind, is in operation at the English Steel Corporation Ltd. It was specially adapted to deal with large cored castings. Two Airless Wheelabrator units are mounted in the cleaning chamber, and the rotating table, controlled by push button, brings the work under the blast streams. It then proceeds round to a Sand Blast room (seen on the left) where the portions of the work which the abrasive streams cannot reach are touched up by pressure blast.

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The Week's News in Brief

Trade Talk

BORAX CONSOLIDATED, LIMITED, has changed its head-office address from Regis House, King William Street, London, E.C.4, to Danes Hill, Oxshott, Surrey. The telephone number is Oxshott 2436-9.

OWING TO DECLINING TRADE, the bath-making section of the Avon Foundry of Jackson, Elphick & Company, Limited, Birkenshaw, Lanarkshire, has been closed down. Orders for baths will be met from stocks. Work will be continued in the other departments.

THE BRITISH ALUMINIUM COMPANY, LIMITED, inform us that, from September 30, the temporary head-office address will be Oakley Manor, Belle Vue Road, Shrewsbury, Shrops. The telegraphic address ("Cryolite Shrewsbury") and telephone number (Shrewsbury 4451) will be unchanged.

EMPLOYEES of Colvilles, Limited, Dalzell and Mossend Steelworks, Lanarkshire, have presented a motor ambulance to the St. Andrew's Ambulance Association for general service during the period of hostilities. The ambulance, which went into service this week, has provision for four stretcher cases.

A CONFERENCE under the auspices of the Association of Scientific Workers will be held in the Royal Technical College, Glasgow, on September 21, when such subjects as working conditions and hours, compensation for accidents, superannuation, the position of assistants, etc., will be discussed. Prof. F. J. Wilson will preside.

A SPITFIRE FUND started a few weeks ago by employees of the General Electric Company, Limited, to raise £5,000 quickly passed the original aim and last week had reached the figure of £7,362. A cheque for this amount was handed to Lord Beaverbrook at the Ministry of Aircraft Production by four employees from different branches of the company.

WITH the approach of longer hours of darkness, the question of factory black-out becomes increasingly urgent. A pamphlet called "Wartime Lighting Restrictions for Industrial and Commercial Premises" can be obtained from the Stationery Office or through any bookseller, which gives complete information on the subject. The price of the pamphlet is 2d., or 3d. post free.

WILD-BARFIELD ELECTRIC FURNACES, LIMITED, of Elecfurn Works, Watford By-Pass, Watford, have been appointed by the manufacturers of the Spekker Steeloscope, Adam Hilger, Limited, of London, to be distributors of this instrument in the United Kingdom. In its simplest form the Steeloscope can be used for the immediate check and sorting of incoming steels from suppliers, or for identification of steels in stores. When fitted with the Insta eyepiece, it is a valuable addition to metallurgical laboratories for accurate visual quantitative analysis.

THE decision of the Broken Hill Proprietary Company, Limited, to manufacture ferro-manganese in Australia has created a domestic market for the high-grade ore which South Australia is able to produce, states the "Mining Review" of the South Australian Department of Mines. The deposits situated at Pernatty Lagoon are now being worked, the ore being shipped to New South Wales from Port Augusta. Prospecting for other deposits is in active progress. It is estimated that 95 per cent. of the manganese ore mined is consumed in the manufacture of steel.

DANGER arising from outbreaks of fire in unattended buildings is stressed in a warning issued by the Ministry of Home Security. It is pointed out that if an outbreak occurs in such a building the fire may not only involve a serious call upon the local fire services through not having been detected at an early stage, but may also serve as a beacon to raiding aircraft. Even a single person in the building can at least summon the fire brigade at once, even if he cannot extinguish the fire before it has got hold. Occupiers of factory and warehouse buildings are strongly urged to secure that at least one person is always on the premises.

GLASGOW Gas Committee had a further meeting last week with representatives of James Nimmo & Company, Limited, regarding the firm's offer to supply coke-oven gas to augment the municipal supply. The Corporation have already entered into a contract with William Dixon, Limited, to take the surplus gas produced at their Govan Ironworks, and the former reluctance of the local authority to make use of cheap industrial gas has now clearly gone. The negotiations with James Nimmo & Company are proceeding satisfactorily. The firm have been asked to submit in writing a definite offer of the quantity of gas they are prepared to deliver.

EXAMINATIONS for admission to Associate Membership and Graduateship of the Institute of Marine Engineers will be held on May 19 to 26, 1941. The Institute's examination for admission of Students is discontinued, the Council having adopted in lieu the Common Preliminary Examination of the Engineering Joint Examination Board. Two of these examinations will be held in 1941, on April 1 to 5 and on October 7 to 11. The examinations are held in London and other centres in Great Britain. Particulars of the syllabuses, exemptions allowable, copies of previous examination papers and latest application dates, may be obtained on application to the Secretary, Institute of Marine Engineers, 73, Amersham Road, High Wycombe, Bucks.

THE civil war in Spain struck a severe blow at the iron and steel industry in that country, for many of the producing centres and the iron-ore mines were the scenes of conflict and disturbance. Recovery under the ægis of the Franco government has been slow. Last year, the output of pig-iron was 456,813 metric tons and that of steel ingots 636,248 tons, each figure being slightly above the 1938 totals. In 1937, pig-iron production was 353,377 tons and steel output 223,149 tons, while in the record year, 1929, the corresponding figures were 748,900 tons and 1,007,500 tons respectively, indicating the great leeway the industry has still to make up. In the Viscayan area, pig-iron output was 314,863 tons last year, against 277,100 tons in 1938, and steel production 406,532 tons against 318,983 tons. The recovery in this region has become more marked during the current year, for output of pig-iron in the first five months totalled 170,000 tons and that of steel ingots 201,000 tons, giving a monthly average substantially above that recorded last year, and approaching for the year the 1929 figures of 425,000 tons of pig-iron and 564,000 tons of steel ingots. Under the current policy of industrialisation, it is expected that a rapid expansion of both iron and steel output will be achieved in the course of the next few months.

Personal

SIR P. P. GINWALA has resumed his seat on the board of the Steel Corporation of Bengal, Limited.

ALDERMAN JAMES ENTWISTLE, who is actively associated with Entwistle Bros., metal merchants, of Bolton, has been appointed a J.P. for the Borough of Bolton.

MR. A. ROEBUCK, M.I.Mech.E., director and foundry manager of Hadfields, Limited, Sheffield, has been appointed representative of the Institution of Mechanical Engineers on the Court of Governors of Sheffield University.

MR. C. W. J. TAFFS, M.Sc. (Eng.), has been appointed assistant secretary of the Institution of Mechanical Engineers. Previous to this appointment Mr. Taffs acted as secretary to the various research committees of the Institution.

MR. W. SLOAN SMITH, of W. H. Arnott, Young & Company, Limited, Glasgow, has given up his appointment as Scottish scrap liaison officer to devote himself to the salvage of wrecks, now a very important undertaking. He has been succeeded by Mr. John Clark, of Robert Love, Limited, as Scottish representative for scrap under the Iron and Steel Control. Mr. Clark is well known in the trade and is a past-president of the Scottish Iron and Steel Scrap Association.

Will

WHITE, W. A., managing director of White's Marine Engineering Company, Limited, Hebburn, and chairman of the White Shipping Company, Newcastle-upon-Tyne ... £140,478

Obituary

MR. ARTHUR S. BURROWS, secretary of the Sheffield Ingot Casting Company, Limited, died suddenly on September 4. Mr. Burrows, who was in his 70th year, was well known in musical circles in Sheffield.

MR. STANLEY P. ROCKWELL was killed aboard his yacht in the Connecticut River after an explosion had occurred on August 11. Mr. Rockwell, who had occupied many important metallurgical positions, was best known in this country as the inventor of the Rockwell hardness tester and the Rockwell dilatometer.

MR. F. G. WARBURTON, managing director of the Harland Engineering Company, Limited, Alloa, for a considerable period, has died at his residence at Stirling. Mr. Warburton began his engineering career with the Lancashire Dynamo Company, and he was associated with the Harland Company's concerns in England and Canada before he went to Scotland.

WE REGRET to announce the death of Sir Harold Carpenter, M.A., Ph.D., F.R.S., Professor of Metallurgy in the Royal School of Mines, South Kensington. Sir Harold, who had been missing since Friday last, was found dead in a stream in the Clyne valley, near Swansea, where he was in the habit of walking. Since the early days of the war he had been working at Swansea University College. Sir Harold was 65 years of age and was knighted in 1929. He was an honorary member of the Institute of British Foundrymen and in its early days lectured before the principal Branches on the subject of the "Growth of Cast Iron," a piece of research work he carried out in collaboration with Rugan. Before being appointed to the chair of metallurgy at South Kensington, he occupied a similar position in the University of Manchester, where both Dr. J. E. Hurst and Mr. J. W. Gardom were students under him. He was a Past-President of both the Iron and Steel Institute and the Institute of Metals, the latter body only recently having honoured him by the award of a platinum medal, whilst the former bestowed upon him the Bessemer medal in 1931. The passing of so distinguished a scientist leaves a gap in the metallurgical world which will be difficult to fill.

WE REGRET to record the death of Mr. Frank Edward McGrah, a director of William Cumming & Company, Limited, of Glasgow and elsewhere. Mr. McGrah joined the firm when it was formed into a limited company in 1900 and took up his duties at the then newly-opened Chesterfield works. He was eventually placed in charge of the works, and became a director in 1919, at about which time he was transferred to Deepfields Works to take over the management. In 1923, when the late Mr. William Cumming died and his place as chairman and managing director was taken by Mr. H. Winterton, Mr. McGrah became vice-chairman and assistant managing director, positions which he occupied until his death. Mr. McGrah was a conscientious and hardworking individual, firm of purpose and devoted to the business which he helped to develop. He was popular with his staff, and became actively interested in some of the social activities in the neighbourhood where he resided. While at Chesterfield he was connected with the adult school movement. Mr. McGrah became a member of the Sheffield Branch of the Institute of British Foundrymen in 1918 and took a considerable interest in its work during the whole period of his membership. He was also hon. treasurer of the Refractories Association of Great Britain.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

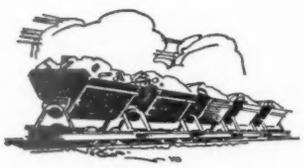
522,790. WESTDEUTSCHE WERKZEUGMASCHINEN AKT.-GES. Method of and apparatus for welding the cages of ball bearings.

522,831. GLACIER METAL COMPANY, LIMITED, and BATE, J. Manufacture of strip metal.

522,842. WAGNER, M. Permanent mould for casting multi-cylinder engine blocks.

522,894. THIEMANN, W. H. A. (Sachtleben Akt.-Ges. für Bergbau und Chemische Industrie). Production of molten iron, steels, or iron-copper alloys.

REFRACTORIES ON PARADE



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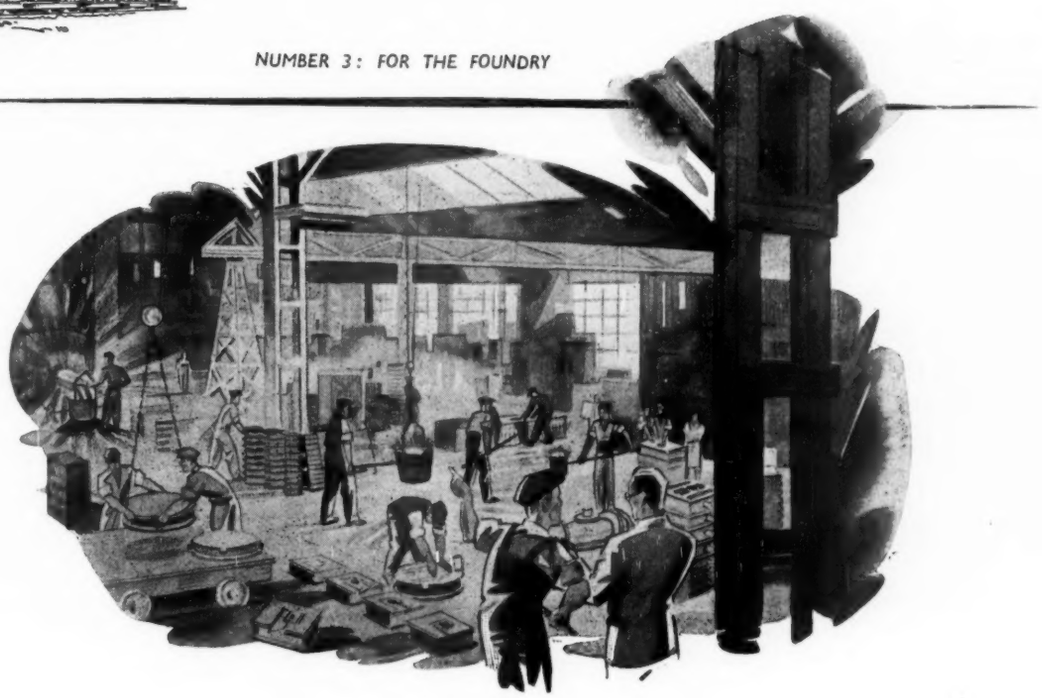

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Raw Material Markets

Iron and steel makers continue to be hard pressed in coping with the demands of the defence programme, and after these requirements have been met there is little surplus material for distribution among other consumers. Overseas customers of the British iron and steel makers continue to place quite considerable inquiries, but only a small proportion can be turned into concrete business. Expansion of the export trade is earnestly desired, and traders have the full co-operation of the Government in any scheme likely to increase sales abroad which can be negotiated without handicapping the completion of contracts of the various Government departments.

Pig-Iron

MIDDLESBROUGH—With ironmakers concentrating on the production of hematite and basic iron, which are in great demand by the steelmakers, output of Cleveland foundry iron remains at a very low ebb. Consumers are, however, able to obtain adequate deliveries of Midland iron, which suits their requirements quite well. Light-castings makers are still badly situated for orders in some cases, although a few have been able to turn their attention to the production of castings in request by Government departments and are thus quite well employed. Heavy engineering concerns are fully occupied, and are committed ahead as far as they are willing to go. Demand for iron from this section is, of course, substantial, but Midland producers are able to despatch adequate tonnages.

Distribution of East Coast hematite is becoming more difficult, as the demand expands from week to week and stocks at makers' yards are practically non-existent. The full output moves into consumption immediately, and only the more urgent requirements can be met without delay. Steelmakers are accounting for a large proportion of the production, and the remainder is readily taken up by users in this area, in Sheffield and in the Midlands.

LANCASHIRE—Demand for pig-iron in this district is fully maintained, and large deliveries are being called for from Midland producers. The position of the light-castings industry shows little improvement, but certain works report better order-books. Other consumers are very active in most cases, especially those works engaged on official contracts. Owing to the heavy demand on hematite from the steelmaking plants, the quantity available for distribution among foundrymen is limited, but by adjusting their mixtures users are generally able to minimise the inconvenience caused in this respect. Indian iron is being used quite freely in this area, thus relieving the pressure on home output, while scrap iron is now much more freely available.

MIDLANDS—Light foundries' demands on high-phosphorus iron are comparatively small, and their needs are being met satisfactorily despite the rather low output. Government departments are making increased use of light-castings makers' products, but short time is still unavoidable at many works. Licences are not being granted very freely for iron for ordinary domestic use, while no export business is at present being done. Consumers of low-phosphorus iron and hematite are not always able to secure the quality generally used by them, but it is often possible to rearrange mixtures to meet the situation. This involves increased use of high-phosphorus iron. It is hoped that better supplies of special ores will enable larger outputs of low-phosphorus iron and hematite to be made in the near future.

SCOTLAND—Current requirements of pig-iron are being well satisfied in this area, and quite good outputs are being recorded. Iron-ore supplies appear to be more plentiful, and the situation has improved considerably since a month or two ago. Consumers would like to be able to accumulate reserve stocks, but at present this is not possible. Activity in the Falkirk district continues to be variable; some light-castings makers are now engaged on Government contracts, but others, relying on ordinary domestic trade, are unable to obtain sufficient iron to enable them to work full time. Consumption of hematite is maintained on a strong scale.

Coke

Although most consumers of foundry coke have large stocks on hand, current demand is quite firm and ovens are well occupied, despite the lack of export business. Buyers are continuing to purchase their current needs, leaving their stocks intact as a precaution against delayed deliveries in the winter. For delivery to Birmingham and Black Country stations, Durham best foundry coke is quoted at 55s. 6d. per ton. This price is subject to change by the Control authorities, so that all business is now transacted with a rise-or-fall clause.

Steel

It is believed that certain changes in the steel distribution scheme will be announced shortly, as experience has revealed the need for modifications of the existing arrangements. It is understood that constructional steel will be most affected by any changes which may be brought about. Demand for steel from the various departments of the Government remains as strong as ever, and no relaxation in the allocation of licences for supplies for other than priority work can be made. Makers are receiving much improved supplies of raw materials, which are enabling them to return excellent production figures. Deliveries of scrap, especially, have been on a much better scale during the past few weeks, and there is every prospect of further expansion in this respect.

Scrap

Large tonnages of all grades of iron and steel scrap continue to become available, and some works have been obliged to restrict deliveries for the time being. Supplies are in all cases being directed to works in the greatest need, and the steelworks are receiving particularly heavy quantities. Collection, preparation and distribution are all being carried out with the minimum of delay, and in districts where users cannot accept further deliveries dumps are being set up within easy reach of the consuming works.

Metals

Consumption of copper in the United Kingdom continues to be at peak levels; no statistics are, of course, available, but the progress of the munitions programme is such that it is self-evident that demand has never before attained present heights. Distribution of supplies rests solely with the Control authorities, who are concentrating primarily on satisfying the requirements of priority consumers. The latter are receiving adequate tonnages and deliveries are sufficient to maintain full production at the consuming plants. The American domestic market continues to be extremely active, with sales well above normal. The price was raised last week by 50 cents per lb. to 11.50 cents, which in the circumstances was not unexpected. Even larger tonnages of the red metal will be requisitioned when the U.S. defence programme gathers momentum. The export market on the other side of the Atlantic continues to be on the quiet side, which, in view of present world conditions, is not surprising. The price of scrap copper in America has been reduced one-eighth cent per lb., which is roughly equivalent to 11 cents refined basis.

The United States Copper Institute reports that production of crude copper in August was (in tons) 79,926, against 79,327 in July; production of refined, 80,851 (90,995); deliveries to domestic consumers, 96,383 (71,226); export shipments, 1,561 (3,532); refined stocks at the end of the month, 198,730 (215,823).

The price decline on the London tin market has continued, and the disparity between prices here and in New York has thus widened still further. There was a sharp recovery on Wednesday, but whether this will be maintained remains to be seen. Some dealers in London have been reported to have urged that the buffer pool authorities should resume purchases, it being suggested that the pool's operating limits, originally £200 to £230 per ton, should be raised to between £250 and £300. Smelters in the United Kingdom continue to forward heavy supplies, but there is reluctance to take further deliveries into stock, there being little prospect of disposing of the metal to overseas destinations owing to the restriction on export licences due to the natural desire to conserve shipping for essential duties. The question of war risks is also a deterring factor, as tin is not covered by war risks insurance. There is little further to report regarding the proposals to establish a tin smelting industry in America, but an unconfirmed message states that important British tin smelters now have representatives in the U.S.A. to watch the position.

London Metal Exchange tin prices this week have been as follow:—

Cash—Thursday, £243 10s. to £244; Friday, £243 to £243 10s.; Monday, £239 to £240; Tuesday, £243 to £244; Wednesday, £245 to £245 10s.

Three Months—Thursday, £246 10s. to £247; Friday, £246 10s. to £247; Monday, £243 10s. to £244; Tuesday, £246 15s. to £247 5s.; Wednesday, £249 to £249 10s.

The brass industry continues to take up very heavy tonnages of high-grade zinc, while zinc alloy die castings are in great request for aircraft manufacture. The spelter position is excellent, and, despite the increasing requirements of works on contracts of national importance, deliveries are fully adequate, with metal to spare for export in the form of finished products. The market in America is very firm and the price is now 6.85 cents per lb. East St. Louis. Buying has recently been on a substantial basis, consumers endeavouring to build up their reserves, which have become depleted.

Business in lead in this country is easily negotiated, as supplies are ample to meet home and export orders.

Reports and Dividends

Minerals Separation, Limited—Interim dividend of 20 per cent.

Qualcast, Limited—Profit for the year to June 30, £99,663; final dividend of 10 per cent., plus a cash bonus of 10 per cent., making 30 per cent. for the year.

Federated Foundries, Limited—Consideration of payment of the half-year's dividend on the 5 per cent. cumulative preference shares is deferred until the final accounts for 1940 are available.

Working After the Siren

(*Continued from page* 187.)

(4) The arrangements for stopping work and taking shelter and for resuming work before the "Raiders Passed" are matters for adjustment between the management and the workpeople, but there must be a system by which the decision to stop work is immediately communicated throughout the works.

(5) A watching system can apply to outdoor work as well as to work in factories.

Emergency Protection

(*a*) Owing to the different types of factories and the great variety of products manufactured, each establishment must work out its own plans.

(*b*) There will be cases where existing shelters can be reached quickly and safely.

(*c*) In the majority of cases, however, some emergency protection will be necessary.

(*d*) For general guidance, the Government has issued a memorandum showing in detail the sort of things that should be attended to and how best to attend to them, such as the treatment of glass—which calls for particular attention—and arrangements by which the workers can take immediate cover by lying down behind traverse walls or behind the plant or material near them or in pits or sub-floor ducts.

(*e*) Only where the structure of the building or any other cause makes it impracticable to provide reasonable protection on the spot and existing shelters cannot be used as emergency cover, should work cease when the siren sounds.

(*f*) The whole question of emergency protection is urgent, and the necessary work should be put in hand at once.

Wind from the right quarter . . .

With a favourable wind the clipper races across the ocean, her tall tapering masts and gleaming spread of snowy canvas providing a picture of loveliness and grace . . .

Industry also demands a satisfactory source of air supply, and instinctively turns to the manufacturers of Fans who have the necessary experience and knowledge which ensure the quality and efficiency of their products.

In Foundries, where comparatively high pressures are required for the supply of air blast to forges and cupolas, "Sirocco" High-Pressure Fans offer dependable service, and numerous installations testify to their excellence and suitability. A wide range of sizes and designs ensures correct fulfilment of individual requirements.

for EFFICIENCY, RELIABILITY and ECONOMY

INSTALL TRADE SIROCCO MARK Cast-Iron

High-Pressure Fans

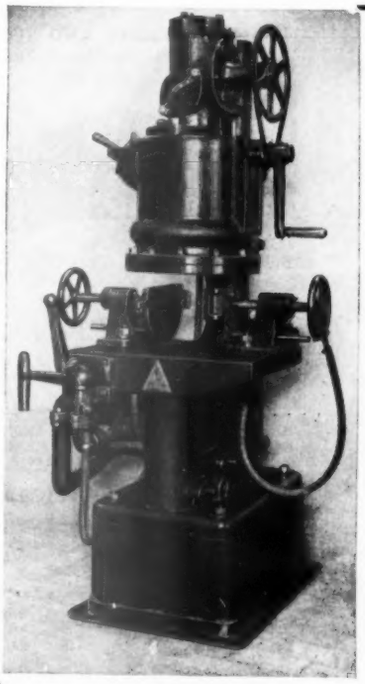
Send for Publication SF26

DAVIDSON & CO. LTD.

SIROCCO ENGINEERING WORKS,

BELFAST, NORTHERN IRELAND

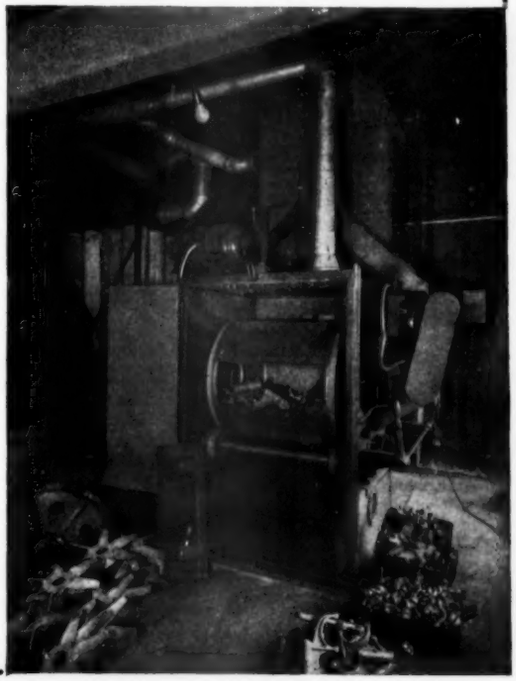
LONDON - MANCHESTER - LEEDS - GLASGOW
BIRMINGHAM - NEWCASTLE - CARDIFF - DUBLIN



WAR-TIME PRODUCTION *conditions involve problems which may be solved by* TITAN PLANT

Titan Core Machines
increase production tenfold as compared with hand methods and achieve better quality at 15% of the former cost.

Sand Wizard
Airless Sandblast Machines effect definite savings of 80% with a minimum labour economy of 65%



THE CONSTRUCTIONAL ENGINEERING Co LTD

Telephone: MIDland 4753-4

TITAN WORKS, BIRMINGHAM 12.

Telegrams: "Structural"

RAW MATERIALS—PRICE LIST

Wednesday, September 18, 1940

COPPER*

	£	s.	d.
Electrolytic	62	0	0
High-grade fire-refined ..	61	10	0
Fire-refined of not less than 99.7 per cent.	61	0	0
Do., do., 99.2 per cent. ..	60	10	0
Black hot-rolled wire rods..	65	10	0

TIN

	£	s.	d.
Standard cash	245	0	0
Three months	249	0	0
Settlement	245	15	0
Official average Cash, Aug.	262	12	$4\frac{7}{11}$
Do. Three Months, Aug.	263	1	$1\frac{7}{11}$
Do. Settlement, Aug. ..	262	10	$8\frac{2}{11}$

SPELTER*

	£	s.	d.
G.O.B. (foreign) (duty paid)	25	15	0
Do. (domestic)	26	10	0
" Prime Western " ..	26	10	0
Refined and electrolytic ..	27	5	0
Not less than 99.99 per cent.	28	15	0

LEAD*

	£	s.	d.
Good soft pig lead (foreign) (duty paid)	25	0	0
Do., do., (Empire and domestic)	25	0	0
English	26	10	0
Sheets, home	34	10	0
Do. export, f.o.b. ..	30	0	0
Pipes, home	34	0	0
Do. export, f.o.b. ..	30	10	0
Tea lead (nom.)		—	

ALUMINIUM

Ingots	£110
Wire, 10g.	nom.
Sheets	nom.
Circles, 20/24g.	nom.

ZINC SHEETS, etc.

	£	s.	d.
Sheets, 10g. and thicker, ex works	39	2	6
Rolled zinc (boiler plates), ex works	37	2	6
Zinc oxide (Red Seal), d/d buyers' premises ..	28	7	6

ANTIMONY

	£	s.	d.
English, 99%, delivered ..	90	0	0
Foreign Regulus, duty paid ..	90 0 0 to 93	0	0
Chinese, prompt shipment, c.i.f. ..	79 0 0 to 82	0	0

QUICKSILVER

	£	s.	d.
Quicksilver, ex-w'hse London	54	10	0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 0d.
Finished bars, 18% tungsten	3s. 10d.
Finished bars, 22% tungsten	4s. 4d.

Per lb. d/d buyers' works.

NICKEL SILVER, etc.

	Per lb.
Ingots for raising ..	9d. to 1/3
Rolled—	
To 9 in. wide ..	1/3 to 1/9
To 12 in. wide ..	1/3½ to 1/9½
To 15 in. wide ..	1/3½ to 1/9½
To 18 in. wide ..	1/4 to 1/10
To 21 in. wide ..	1/4½ to 1/10½
To 25 in. wide ..	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
to 10g.	1/6½ to 2/1½

with extras according to gauge.

Special 5ths quality turning rods in straight lengths, 1/5½ upwards.

Maximum prices per long ton delivered to buyers' premises.

FERRO-ALLOYS AND STEEL-MAKING METALS

(all prices nominal)

Ferro-silicon—	£ s. d.
25%	18 10 0
45/50%	21 10 0
75%	31 0 0
Ferro-vanadium—	
35/50%	15/6 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free ..	6/- lb. Mo.
Ferro-titanium—	
20/25% carbon-free ..	1/9 lb.
Ferro-tungsten—	
80/85%	5/1 lb.
Tungsten metal powder—	
98/99%	5/2½ lb.
Ferro-chrome—	
2/4% car.	—
4/6% car.	47 0 0
6/8% car.	47 0 0
8/10% car.	—
Ferro-chrome—	
Max. 2% car.	—
Max. 1% car.	—
Max. 0.5% car.	—
70% carbon-free	—
Nickel—99.5/100%	£190 to £195
" F " nickel shot ..	175 0 0
Ferro-cobalt, 98/99% ..	8/9 lb.
Metallic chromium—	
96/98%	3/9 lb.
Ferro-manganese—	
76/80% loose	18 0 0
76/80% packed	19 10 0
Metallic manganese—	
94/96% carbon-free ..	1/9 lb.

Per ton unless otherwise stated, basis 2-ton lots, d/d Sheffield works.

SCRAP*

	£ s. d.	£ s. d.
SOUTH WALES—		
Short heavy steel, not ex. 24-in. lengths.. ..	3 16 6	to 3 19 0
Heavy machinery cast iron	4 6 6	
Ordinary heavy cast iron	4 1 6	
Cast-iron railway chairs	4 6 6	
Medium cast iron ..	3 17 9	
Light cast iron	3 13 0	
MIDDLESBROUGH—		
Short heavy steel	3 14	3 to 3 16 9
Heavy machinery cast iron	4 11 3	
Ordinary heavy cast iron	4 8 9	
Cast-iron railway chairs	4 8 9	
Medium cast iron ..	3 19 0	
Light cast iron	3 14 0	
BIRMINGHAM DISTRICT—		
Short heavy steel	3 9	3 to 3 11 9
Hematite ingot mould	5 10 9	
Heavy machinery cast iron	4 11 9	
Ordinary heavy cast iron	4 7 0	
Cast-iron railway chairs	4 7 0	
Medium cast iron ..	3 19 9	
Light cast iron	3 14 9	
SCOTLAND—		
Short heavy steel	3 14	0 to 3 16 6
Heavy machinery cast iron	4 13 9	
Ordinary heavy cast iron	4 8 9	
Cast-iron railway chairs	4 13 9	
Medium cast iron ..	3 16 9	
Light cast iron	3 11 9	

* Delivered free to consumers' works in England and Wales. For deliveries of cast-iron scrap free to consumers' works in Scotland, the above prices less 2s. per ton, but plus actual cost of transport or 6s. per ton, whichever is the less. All prices: Plus 2½ per cent. dealers' remuneration: 50 tons and upwards over three months 2s. 6d. extra

PIG-IRON*

N.E. COAST (d/d Tees-side area)—	
Foundry No. 1	123/-
" No. 3	120/-
" No. 4	119/-
Forge No. 4	119/-
Hematite No. 1	131/-
Hematite M/Nos.	130/6
N.W. COAST—	
Hem. M/Nos. d/d Glas. ..	131/-
" d/d Birm.	142/6
MIDLANDS (d/d Birmingham dist.)—	
Staffs No. 4 forge	121/-
" No. 3 fdry.	122/-
Northants forge	118/6
" fdry. No. 3 ..	119/6
" fdry. No. 1 ..	122/6
Derbyshire forge	121/-
" fdry. No. 3 ..	122/-
" fdry. No. 1 ..	125/-
Phosphorus 0.5% to 0.75%	129/6
Phosphorus 0.1% to 0.5%	132/6
SCOTLAND—	
Foundry No. 1, Grangemouth	119/9
" No. 3, Grangemouth	117/3
Cleveland No. 3, Glasgow	123/-
" " Falkirk ..	120/-
Scottish hem. M/Nos. d/d..	131/-
SHEFFIELD (d/d district)—	
Derby forge	118/6
" fdry. No. 3 ..	119/6
Lincs forge	118/6
" fdry. No. 3 ..	119/6
W.C. hematite	136/6
LANCASHIRE (d/d eq. Man.)—	
Derby fdry. No. 3 ..	125/-
Staffs fdry. No. 3	125/-
Northants fdry. No. 3 ..	123/6
Cleveland fdry. No. 3 ..	125/-
Cylinder and Refined Irons	
North Zone..	168/-
South Zone..	170/6
Refined Malleable	
Birmingham and S. Staffs ..	165/6
Cold Blast	
South Staffs	217/-

* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms and Slabs.

BASIC:	£ s. d.
Soft, u.t., 100-ton lots ..	10 10 0
Tested, up to 0.25% C. ..	10 15 0
Tested, 0.25 to 0.33% C.	10 17 6
Tested, 0.33 to 0.41% C...	11 0 0
Hard (0.42 to 0.60% C.)..	11 17 6
" (0.61 to 0.85% C.)..	12 7 6
" (0.86 to 0.99% C.)..	12 17 6
" (1% C. and up) ..	13 7 6
Silico-manganese	14 5 0
Free-cutting	12 10 0
SIEMENS MARTIN ACID	
Up to 0.25% C.	13 15 0
Case-hardening	14 12 6
Silico-manganese	14 10 0

Billets, Blooms and Slabs for Forging and Stamping.

Basic soft, up to 0.25% C. ..	12 2 6
Basic hard, 0.41 to 0.60% C.	12 10 0
Acid, up to 0.25% C. ..	14 5 0

Other Semi-products, etc.

Tin bars	10 7 6
Sheet bars	10 7 6
*Wire rods, soft basic ..	15 4 0
" hard basic ..	18 12 6
" free-cutting ..	17 12 6
acid	22 3 6

* Subject to rebate.

FINISHED STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel bars, sections plates joists and hoops is obtainable in the home trade under certain conditions.]

	£	s.	d.
Plates, ship (N.E. Coast) ..	14	3	0
Boiler plts. (N.E. Coast) ..	15	0	6
Chequer plts. (N.E. Coast)	15	13	0
Angles, over 4 un. ins. ..	13	13	0
Tees, over 4 un. ins. ..	14	13	0
Joists, 3 in. × 3 in. and up	13	13	0
Rounds and squares, 3 in. to 5½ in.	14	13	0
Rounds under 3 in. to ⅜ in. (untested)	15	8	6
Flats—over 5 in. wide ..	13	18	0
" 5 in. wide and under ..	15	8	6
Rails, heavy, f.o.t. ..	12	15	6
Hoops	16	3	6
Black sheets, 24 g. (4 t. lots)	19	7	6
Galv. cor. shts. (")	22	12	6
Galv. flat shts. (")	23	2	6
Galv. fencing wire, 8g. plain	24	7	6

FINISHED IRON

	£	s.	d.
CROWN IRON:			
England and Wales ..	15	2	6
Scotland	15	2	6
Ireland, f.o.q.	15	15	0
No. 3 BARS:			
England and Wales ..	12	5	0
Scotland	13	7	6
Ireland, f.o.q.	12	17	6
No. 4 BARS:			
England and Wales ..	12	15	0
Scotland	13	12	6
Ireland, f.o.q.	13	7	6
STRIP:			
England and Wales ..	16	10	0
STAFFS MARKED BARS, f.o.t...	18	0	0

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated August 27, 1940.

	Dols.
No. 2 foundry, Phila.	24.84
No. 2 foundry, Valley	23.00
No. 2 foundry, Birm.	19.38
Basic, Valley	22.50
Malleable, Valley..	23.00
Grey forge, Valley	22.50
Ferro-mang., seaboard	120.00
O.-h. rails, h'y, at mill	40.00
Billets	34.00
Sheet bars	34.00
	Cents.
Iron bars, Chicago	2.25
Steel bars	2.15
Tank plates	2.10
Beams, etc.	2.10
Wire rods	2.00
Skelp, grooved steel	1.90
Steel strip	2.10
Steel sheets	2.10
Sheets, galv., 24 g.	3.50
Wire nails	2.55
Plain wire	2.60
Tinplates, 100-lb. box	$5.00

COKE (at ovens)

Welsh foundry	42/6 to 44/-
" furnace	31/6 to 33/-
Durham foundry	39/6
" furnace	33/6
Scottish foundry	42/6 to 47/6
" furnace	31/6

TINPLATES

f.o.b. Bristol Channel ports

I.C. cokes	20 × 14 per box	27/- to 28/-
"	28 × 20 "	54/- to 56/-
"	20 × 10 "	38/6 to 39/6
"	18¾ × 14 "	28/3 to 29/-
C.W.	20 × 14 "	25/- to 26/-
"	28 × 20 "	50/- to 52/-
"	20 × 10 "	37/6 to 38/6
"	18¾ × 14 "	.. 27/-

NON-FERROUS SCRAP

(Official Maximum Prices, per ton ex Works.)

	£	s.	d.
Bright untinned copper wire, in crucible form or in hanks	57	10	0
No. 1 copper wire	57	0	0
No. 2 copper wire	55	10	0
Copper firebox plates, cut up	57	10	0
Clear untinned copper, cut up	56	10	0
Brazierv copper	53	10	0
Q.F. process and shell-case brass, 70/30 quality, free from primers	49	0	0
Clean fired 303 S.A. cartridge cases	47	0	0
70/30 turnings, clean and baled	43	0	0
Brass swarf, clean, free from iron and commercially dry	34	10	0
New brass rod ends, 60/40 quality	38	10	0
Hot stampings and fuse metal, 60/40 quality	38	10	0
Admiralty gunmetal, 88-10-2, containing not more than ¼ per cent. lead or 3 per cent. zinc, or less than 9½ per cent. tin	72	0	0

NEW BRASS TUBES, etc.

	Per lb.
Solid drawn tubes	13½d.
Brazed tubes	15½d.
Rods, drawn	11½d.
Rods, extd. or rlld.	8½d.
Sheets to 10 w.g.	10½d.
Wire	10½d.
Rolled metal	9½d.
Yellow metal rods	8½d.

COPPER TUBES, etc.

Solid drawn tubes	14½d.
Brazed tubes	14½d.
Wire	9½d.

PHOSPHOR BRONZE

	Per lb. basis
Strip	13½d.
Sheet to 10 w.g.	13½d.
Wire	15½d.
Rods	15½d.
Tubes	20½d.
Castings	17d.

Delivery 3 cwt. free.
10% phos. cop. £35 above B.S.
15% phos. cop. £40 above B.S.
Phosphor tin (5%) £40 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

AVERAGE MONTHLY PRICES OF CLEVELAND No. 3 PIG-IRON.*

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1900	67 10	68 10	73 10	76 2	74 2	68 6	69 3	71 4	70 9	67 8	63 6	53 6	68 9
1901	48 0	46 6	45 8	45 5	45 10	44 7	44 6	45 3	45 3	45 3	43 6	43 1	45 3
1902	43 11	46 7	46 9	47 11	48 10	49 7	50 9	52 1	53 6	52 9	50 9	47 11	49 3
1903	47 3	48 9	51 10	49 0	46 1	46 2	46 7	46 8	45 7	43 6	42 10	41 11	46 4
1904	42 3	42 7	43 3	44 7	44 0	42 10	42 9	43 3	43 1	43 9	46 1	48 7	43 11
1905	48 11	48 0	49 6	50 1	51 5	45 6	45 9	47 5	48 8	52 11	52 9	53 3	49 6
1906	53 9	50 1	48 1	48 8	50 2	50 3	50 6	53 0	54 6	56 8	58 6	62 4	53 6
1907	60 4	56 6	54 10	56 6	61 1	58 1	57 8	57 8	55 7	54 8	50 8	50 0	56 2
1908	48 5	49 3	51 7	51 10	51 6	51 2	50 0	51 4	52 0	49 8	49 4	48 11	50 8
1909	48 10	48 1	46 9	47 9	48 4	48 9	48 6	50 5	51 3	51 11	51 2	50 7	49 4
1910	51 10	51 3½	51 7½	50 10	49 10	49 2	48 10	49 8½	49 3½	49 7½	49 6½	49 10	50 4
1911	49 11½	49 2½	48 5	46 11	46 4	46 6	46 11½	47 4	47 0	46 7	47 4½	48 1	47 7
1912	50 0	49 5½	51 1½	53 7½	54 4	55 1	57 5½	64 6½	61 7½	66 8½	67 8	68 0	58 5½
1913	66 11½	63 8½	64 8	67 1½	66 3	56 9½	56 3½	55 8	55 4	53 0	50 1	50 4	58 10
1914	50 11	51 5½	51 0½	51 4½	51 6	51 6½	51 5	52 3	51 5	50 1	50 3	53 0	51 4½
1915	55 7	56 6	61 0	66 7	65 2	66 10	65 4	66 0½	65 3	65 11	69 10½	75 7½	65 7
1916	80 2	91 6	87 4½	86 10	82 6	82 6	87 6	87 6	87 6	87 6	87 6	87 6	85 10
1917	87 6	87 6	87 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	95 0	99 3
1918	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0
1919	95 0	95 0	95 0	95 0	152 6	160 0	160 0	160 0	160 0	160 0	160 0	160 0	137 3
1920	175 0	175 0	187 6	200 0	208 0	217 6	217 6	221 0	225 0	225 0	225 0	225 0	209 3
1921	222 6	195 0	150 0	126 0	120 0	120 0	120 0	136 3	127 0	120 0	110 0	100 0	137 4
1922	92 6	90 0	90 0	90 0	90 0	90 0	89 0	87 3	92 6	92 6	92 6	91 8½	90 7½
1923	94 6	108 9	125 6	129 4½	128 5	136 0	128 1½	121 11	97 1½	97 0	100 0	100 0	110 6½
1924	99 10	97 3	91 9	93 9	91 9	89 10½	87 9	85 0	82 5½	80 2	81 9	81 9	88 7½
1925	80 4	78 10½	78 0	78 3	76 0	73 10½	71 7½	69 10½	68 1½	66 7	66 0	66 0	72 10½
1926	69 4½	70 0	70 0	70 0	72 6	75 10½	86 7½	90 0	93 10½	117 10	120 0	99 0	86 3
1927	85 0	83 1½	81 0	80 0	73 9	70 0	70 0	68 9	67 6	67 6	66 10½	65 0	73 2½
1928	65 0	65 0	65 6	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	65 9½
1929	66 0	66 9	67 0	68 1½	69 5	71 10½	72 9	72 6	72 6	72 6	72 6	72 6	70 4½
1930	72 6	72 6	70 0	67 6	67 6	67 6	67 6	64 6	63 6	63 6	63 6	63 6	66 11½
1931	59 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 7
1932	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6
1933	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6
1934	62 6	65 0	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	66 10½
1935	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	69 4½	70 0	67 10½
1936	70 0	70 0	70 0	70 0	70 0	70 0	75 0	75 0	75 0	75 0	75 0	81 0	73 0
1937	81 0	81 0	81 0	81 0	81 0	81 0	101 0	101 0	101 0	101 0	106 0	106 0	91 10
1938	109 0	109 0	109 0	109 0	109 0	109 0	109 0	109 0	109 0	109 0	109 0	109 0	109 0
1939	99 0	99 0	99 0	99 0	99 0	99 0	99 0	99 0	99 0	99 0	108 0	108 0	100 6
1940	108 0	111 0	111 0	111 0	111 0	111 0	120 0	120 0	—	—	—	—	—

* Delivered Middlesbrough area for years 1933 and onwards. Prior to 1933, prices were f.o.t. furnaces. NOTE: Prices have been subject to a rebate of 5/- per ton since November 1, 1937.

WILLIAM JACKS & COMPANY
LIMITED
WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.
13, RUMFORD STREET, LIVERPOOL.

PIG IRON

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY
LIMITED
CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2
ZETLAND ROAD, MIDDLESBROUGH.

Notice

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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

FOUNDRY MANAGER wanted to take full control of Foundry at present turning out approximately 200 tons of miscellaneous castings per week, including high-class engine work, condensing plants, etc., with large and small capacities. Must have expert knowledge of Admiralty requirements, also accustomed to repetition work, both large and small.—Write, stating age, full qualifications, previous experience, with recommendations and salary required, to Box 470, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

WANTED.—Manager for jobbing engineering ironfoundry. State experience, age and salary.—Box 468, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

EMPLOYMENT REGISTER.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

MALLEABLE and grey cast iron foundry manager seeks re-engagement similar position or as consultant to firm starting or developing malleable cast iron. First-class record. (370)

MANAGER or Assistant Foundry Manager desires re-engagement; Light Alloys to Air Ministry Specs.; Alloy Cast Iron; Grey Iron; green sand; dry sand. Jobbing and machine moulding; pattern shop. (391)

PATENT

THE Proprietors of Patent No. 374345 for "Improvements in or relating to Wire Ropes" are desirous of entering into arrangements by way of licence and otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country. Address all communications in the first instance to HASELTINE LAKE & Co., 28, Southampton Buildings, Chancery Lane, London, W.C.2.

MACHINERY

IDLE PLANT

won't help the country!

For the successful prosecution of the war the need for Plant and Machinery is as urgent as the need for men. Have you any surplus plant which might be set to work in the national interests? *We will either purchase outright, or negotiate the sale for you on a commission basis*

GEORGE COHEN

SONS & CO., LTD. (Est. in the year 1834)

Wood Lane, LONDON, W.12. SHEpherds Bush 2070.
Stanningley Works, Nr. LEEDS. Stanningley 71171.
And at Birmingham, Sheffield, Manchester, Bristol, etc., etc.

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